PARASITOLOGY

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. 4

H. K. LEWIS & CO., LTD., 136, GOWER STREET, LONDON, W.C. 1
WHELDON & WESLEY, LTD., 2–4, ARTHUR STREET, NEW OXFORD STREET, LONDON, W.C. 2
CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(Agent for the United States and Canada)
BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

All rights reserved

PARASITOLOGY

EDITED BY

GEORGE H. F. NUTTALL, F.R.S.
QUICK PROFESSOR OF BIOLOGY AND DIRECTOR OF THE MOLTENO INSTITUTE
FOR RESEARCH IN PARASITOLOGY IN THE UNIVERSITY OF CAMBRIDGE

VOLUME XIV 1922

CAMBRIDGE
AT THE UNIVERSITY PRESS
1922

PRINTED IN GREAT BRITAIN

Medical Lib.

Vol. 14, No. 1 April, 1922

PARASITOLOGY

EDITED BY

GEORGE H. F. NUTTALL, M.D., Ph.D., Sc.D., F.R.S.
Quick Professor of Biology and Director of the Molteno Institute for Research in Parasitology in the University of Cambridge

CAMBRIDGE UNIVERSITY PRESS
C. F. CLAY, MANAGER
LONDON: FETTER LANE, E.C. 4
ALSO
H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C. 1
WHELDON AND WESLEY, LTD., 28, ESSEX STREET, STRAND, LONDON, W.C. 2
CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES AND CANADA)
BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

Fifteen Shillings net

[*Issued* 25 *April*, 1922]

The University of Chicago Press

The Anatomy of Woody Plants.

By E. C. JEFFREY, Professor of Plant Morphology in Harvard University. The author is easily the leading American Authority on the anatomy of plants. His book aims to describe, analyze, and discuss the anatomical structure of the most important families of plants. It does for the anatomy of plants what so many textbooks have done for the human anatomy. 306 figures and illustrations; x+478 pages, cloth; 28*s* 6*d* net.

The Evolution of Sex in Plants. (*The University of Chicago Science Series.*)

By JOHN M. COULTER, Head of the Department of Botany, The University of Chicago. In this work the prevalence of a sexual reproduction among plants is emphasized, the author showing that in many of the lower forms sexual reproduction is unknown. Sexual reproduction is described historically as the last method of reproduction attained among plants, and as not replacing but as being added to earlier methods. Thus we have variation, and in sex reproduction extreme individuality also. The more detailed parts of the discussion are illustrated by cuts and drawings introduced into the text. x+140 pages, 12mo, cloth; 7*s* 6*d* net.

Individuality in Organisms. (*The University of Chicago Science Series.*)

By CHARLES MANNING CHILD, Associate Professor of Zoology in the University of Chicago. Professor Child's work is an attempt to state, and to present evidence in support of, a conception of the nature of organic individuality which the author has developed as a result of fifteen years of investigation of the processes of reproduction and development in the lower animals. In these forms, organic individuality appears in relatively simple terms, and it is here that we must look for the key to the problem of individuality in the higher animals and man.

The author has addressed himself with remarkable success to showing the wide range of applicability of the conception of individuality of various fields, with the result that the book appeals not only to the physiologist and to the botanist, but also to the neurologist, to the psychologist, and even to the sociologist. x+212 pages, small 12mo, cloth; 9*s* net.

Sold in the British Empire (except Canada) by

Cambridge University Press, Fetter Lane, London, E.C. 4

Cambridge University Press

AN INTRODUCTION TO THE STUDY OF CYTOLOGY. By L. DONCASTER, Sc.D., F.R.S., Derby Professor of Zoology in the University of Liverpool. Demy 8vo. With 24 plates and 31 text-figures. 24*s* net.

GROWTH AND FORM. By D'ARCY WENTWORTH THOMSON, C.B., D.Litt., F.R.S., Professor of Natural History in the University of St Andrews; Scientific Member of the Fishery Board for Scotland. Demy 8vo. With 408 illustrations. 30*s* net.

ZOOLOGY. An Elementary Textbook. By Sir A. E. SHIPLEY, G.B.E., Sc.D., F.R.S., and E. W. MACBRIDE, D.Sc., F.R.S. Fourth edition. Demy 8vo. With 360 illustrations. 22*s* 6*d* net.

THE FLEA. By H. RUSSELL, B.A., F.Z.S., M.B.O.U. Roy. 16mo. With 9 illustrations. Cloth, 2*s* 6*d*. Limp Lambskin, 3*s*. Cambridge Manuals of Science and Literature.

THE CAUSES OF TUBERCULOSIS. Together with some Account of the Prevalence and Distribution of the Disease. By L. COBBETT, M.D., F.R.C.S. With 23 plates and 8 diagrams. 26*s* net.

INDUSTRIAL COLONIES AND VILLAGE SETTLEMENTS FOR THE CONSUMPTIVE. By Sir GERMAN WOODHEAD, K.B.E., V.D., M.D., LL.D., and P. C. VARRIER-JONES, M.R.C.S., L.R.C.P., Tuberculosis Officer for the County of Cambridge. With a Preface by Sir CLIFFORD ALLBUTT. Demy 8vo. Paper covers, 9*s* net; cloth, 10*s* 6*d* net.

Cambridge University Press, Fetter Lane, London, E.C. 4; C. F. Clay, Manager

Med.
Foxes

CONTENTS

No. 1 (April)

PAGE

Baylis, H. A. Observations on certain Cestodes of Rats, with an Account of a New Species of *Hymenolepis*. (With 4 Text-figures) . . . 1

Baylis, H. A. Note on the Habitat and Structure of *Crassicauda* [Nematoda]. (With 3 Text-figures) 9

Dudgeon, G. C. Occurrence of *Heligmosomum brasiliense* Trav. in England 13

Hopwood, A. T. An interesting case of *Cysticercus fasciolaris* infesting the Brown Rat. (With Plate I) 14

Ghosh, Ekendranath. On a New Ciliate, *Balantidium blattarum*, sp. nov., Intestinal Parasite in the Common Cockroach (*Blatta americana*). (With 1 Text-figure) 15

Cunliffe, Norman. Some observations on the Biology and Structure of *Ornithodorus savignyi* Andouin. (With 3 Text-figures) 17

Allen, J. A. and Wickware, A. B. A Preliminary Note on Parasites infesting Domesticated Silver Black Foxes in Canada 27

Bezzi, Professor M. On the Dipterous Genera *Passeromyia* and *Ornithomusca*, with Notes and Bibliography on the Non-Pupiparous Myiodaria parasitic on Birds 29

Pavlovsky, E. N. Description of a Box for Collecting and Transporting Living Insects, etc. (With 6 Text-figures) 47

Caldwell, Fred C. An Accidental Infection with *Uncinaria* 51

Bullamore, Geo. W. *Nosema apis* and *Acarapis* (*Tarsonemus*) *woodi* in relation to Isle of Wight Bee Disease 53

Hill, Laurence. Three New Species of *Trichodectes* from *Cephalophus monticola* and *Procavia capensis* from South Africa. (With Plate II) . 63

Morris, Hubert M. On the Larva and Pupa of a Parasitic Phorid Fly—*Hypocera incrassata* Mg. (With Plate III and 4 Text-figures) . . 70

Ferris, G. F. The Mallophagan Family *Trimenoponidae*. (With 8 Text-figures) 75

Boulenger, C. L. On *Ascaris vitulorum* Goeze. (With 3 Text-figures) . 87

Nuttall, George H. F. Notes bearing on Van Beneden, Leuckart and Sonsino whose portraits appear in *Parasitology*, xiv, No. 1. (Portrait-plates XII–XIV) 93

No. 2 (June)

PAGE

Nuttall, George H. F. The Molteno Institute for Research in Parasitology, University of Cambridge, with an Account of how it came to be founded. (With Plates IV–VI and 6 Text-figures) . . . 97

Yokogawa, Sadamu. The Development of *Heligmosomum muris* Yokogawa, a Nematode from the Intestine of the Wild Rat. (With Plates VII–XII and 8 Text-figures) 127

Haviland, Maud D. On the Larval Development of *Dacnusa areolaris* Nees (Braconidae), a Parasite of Phytomyzinae (Diptera), with a Note on certain Chalcid Parasites on Phytomyzids. (With 5 Text-figures) . 167

Nuttall, George H. F. Notes bearing on Dufour, von Siebold and Goodsir, whose portraits appear in *Parasitology*, xiv, No. 2. (Continuing the Series begun in Vol. xiii.) (Portrait-plates XV–XVII) . 174

Ferris, G. F. and Cole, F. R. A Contribution to the Knowledge of the *Hippoboscidae* (Diptera Pupipara). (With 20 Text-figures). . . 178

Boulenger, C. L. The Structure and Systematic Position of *Strongylus polygyrus*. (With 4 Text-figures) 206

Leigh-Sharpe, W. Harold. A Parasitic Copepod belonging to the Genus *Medesicaste* (Krøyer), and its Relation to the Tumours it produces on the Fish, *Trigla gurnardus*. (With 7 Text-figures) 214

Keilin, D. Parasitism and Symbiosis. (A Review) 220

Nos. 3 and 4 (December)

Kudo, R. On the Morphology and Life-history of a Myxosporidian, *Leptotheca ohlmacheri*, parasitic in *Rana clamitans* and *R. pipiens*. (With Plates XIII–XX, containing Figs. 1–111) 221

Cawston, F. G. Some Notes on the Differentiation of closely-allied Schistosomes 245

Faust, Ernest Carroll. Notes on Larval Flukes from China. (With Plates XXI and XXII) 248

Flattely, F. W. Considerations on the Life-history of Tapeworms of the Genus *Moniezia* 268

Balfour, Andrew. Observations on Wild Rats in England, with an account of their Ecto- and Endoparasites. (With Plates XXIII and XXIV, 1 Text-figure and 2 Charts) 282

Vincent, Mary. On the Life-history of a New Gregarine: *Pyxinia anobii* n. sp. Intestinal Parasite of *Anobium paniceum* L. (Coleoptera). (With 5 Text-figures) 299

PAGE

RICHARDS, MAJOR W. G. Note on *Dracunculus medinensis* (Guinea-worm) 307

PAVLOVSKY, E. N. and ANITCHKOV, N. N. *Tetracotyle sogdiana*—a New Trematode Parasite of the Fish, *Schizothorax intermedius*, with a description of adhesive peritonitis produced by the parasite in its host. (With Plate XXV) 309

IWANOW, E. A Contribution to the Biology of *Trypanosoma equiperdum* . 315

GRAY, R. A. HARPER. The occurrence of a Leech (*Trocheta subviridis*) in an Allotment 320

WARBURTON, CECIL. The Warble-Flies of Cattle. *Hypoderma bovis* and *H. lineatum*. (With 3 Text-figures) 322

DOBELL, CLIFFORD. The Discovery of the Coccidia 342

BROWNE, FRANK BALFOUR. On the Life-history of *Melittobia acasta*, Walker; a Chalcid Parasite of Bees and Wasps. (With Plate XXVI) . 349

GHOSH, EKENDRANATH. On a New Ciliate, *Balantidium ovatum*, sp. nov., an Intestinal Parasite in the Common Cockroach (*Blatta americana*). (With 1 Text-figure) 371

KOSTYLEV, DR N. Sur les Acanthocéphales de l'Eider (*Somateria mollissima* L.). (With 5 Text-figures) 372

NICOLL, WILLIAM. Recent progress in our knowledge of Parasitic Worms and their relation to the public health 378

BAYLIS, H. A. Notes on the Collection and Preservation of Parasitic Worms 402

BULLOCH, WM, DOBELL, CLIFFORD, and NUTTALL, GEORGE H. F. Notes bearing on Spallanzani, Lewis and Cobbold, whose portraits appear in *Parasitology*, XIV, Nos. 3–4. (Continued from p. 177.) (Portrait-plates XVIII–XX) 409

INDEX OF AUTHORS 419

INDEX OF SUBJECTS 421

VOLUME XIV APRIL, 1922 No. 1

OBSERVATIONS ON CERTAIN CESTODES OF RATS, WITH AN ACCOUNT OF A NEW SPECIES OF *HYMENOLEPIS*.

BY H. A. BAYLIS, M.A., D.Sc.

(*Published by permission of the Trustees of the British Museum.*)

(With 4 Text-figures.)

DURING some investigations in which he has been engaged on the internal parasites of rats in the British Isles, Mr G. C. Dudgeon, of the Wellcome Bureau of Scientific Research, has kindly submitted to the writer examples of all the species of adult Cestodes found.

Two species of *Hymenolepis* are well known to occur in the brown and black rats, viz. *H. diminuta* and a smaller form most commonly referred to in literature as *H. murina*. The latter is of exceptional interest on account of the vexed question as to its identity with the human parasite *H. nana*. In more or less direct connection with this question a very extensive literature has grown up, which it is impossible to review fully here. It may be said, however, that the general result of researches by numerous authors, while still inconclusive, tends to show that the forms occurring in man and the rat are morphologically identical, while on physiological grounds there is some justification for regarding them as distinct species, subspecies, or at least varieties. This view is held on account of the many unsuccessful attempts that have been made to infect rats with *H. nana* of human origin, and on the other hand to infect man with "*H. murina*."

A few of the more important contributions to the subject may be mentioned. The celebrated researches of Grassi and his collaborators (1887–1892) along these lines led them to regard *nana* as a variety of "*murina*," and they concluded that infection was capable of transmission from rats to man, though the experimental evidence was very scanty. On the other hand, on morphological grounds, as well as from considerations of geographical distribution, other authorities (Moniez, Blanchard, von Linstow) regarded the two forms as distinct species. The last-named author (1896) gives comparative measurements and other data compiled from his own and numerous other authors' observations, which he appears to have regarded as conclusive, but which have not proved equally convincing to later writers. Stiles (1906) favoured the separation of the forms as "host subspecies," and renamed "*H. murina*"

SDB

H. nana fraterna. A recent important contribution to the question is that of Joyeux (1919). This author returns to the position taken up by v. Linstow, in regarding the forms as distinct species. He proposes to call the rat-parasite *H. fraterna*.

The supposed morphological differences between *H. nana* and "*H. murina*" must be discussed more fully later. It will be well, however, first to consider Mr Dudgeon's *Hymenolepis* material, which appears to have rather important bearings on this question.

Among the material there occur three forms, viz.

(1) *Hymenolepis diminuta* (Rud.).

(2) A form which may be called *H. nana fraterna*.

(3) A form very closely related to the latter, but quite distinct, which does not appear to be referable to any of the other species of *Hymenolepis*

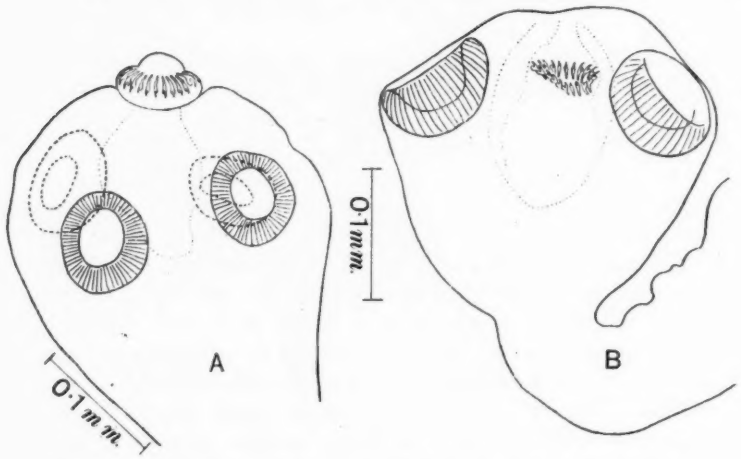


Fig. 1. *Hymenolepis longior*. Two scolices in dorsal or ventral view: *A.*, with evaginated rostellum; *B.*, with invaginated rostellum.

from rats or their relatives, of which the descriptions are accessible to the writer (see list, p. 7). This form, accordingly, it is proposed to regard as a new species.

Hymenolepis longior, sp. n.

The worm is very slender, fragile and semi-transparent. Complete specimens attain a length of 45 mm., or even 60 mm. in a stretched condition. The maximum width of the strobila (usually occurring in the region of the gravid segments, but sometimes, in contracted specimens, more anteriorly), is from 0·42 to 0·53 mm. In exceptionally contracted individuals it may even reach 0·65 mm. The scolex is flattened dorso-ventrally, more or less rectangular in transverse section, and assumes very different shapes (Fig. 1)

according to the state of contraction. It is, in any case, considerably wider than the "neck" which follows it. Its diameter, measured from side to side, is from 0·21 to 0·26 mm., with a mean measurement of about 0·24 mm. The suckers, situated somewhat laterally, have an outside diameter of 0·075–0·093 mm. There is a well-developed rostellum, having a diameter of 0·07–0·08 mm., and armed with a single row of hooks of the characteristic shape, 21 or 22 in number (most commonly 22), and 19–20 μ in length.

The "neck" is unsegmented for some little distance behind the scolex. The total number of recognisable segments in the strobila may reach 600 or more. Rudiments of genital organs begin to be recognisable at about the 50th segment from the anterior end; "mature" segments—*i.e.* segments

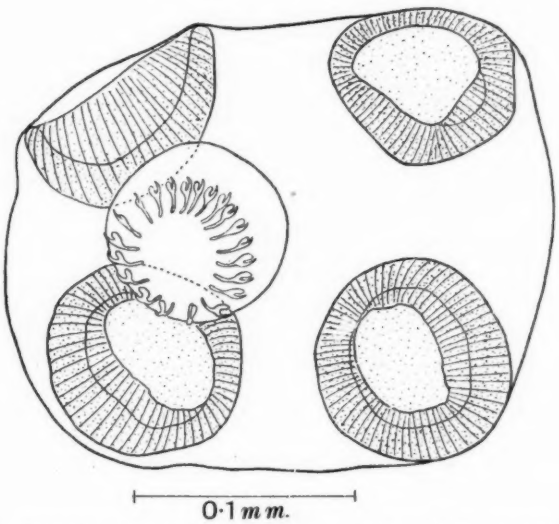


Fig. 2. *Hymenolepis longior.* Scolex, with evaginated rostellum, viewed *en face.*

containing male and female organs in a state of full functional activity—at about the 250th. The number of gravid segments at the posterior end varies between (roughly) 60 and 100. The segments are broader than long throughout, though the length tends to become nearly equal to the breadth in the more posterior segments, and the ratio of length to breadth is (except in greatly contracted specimens) much higher in mature segments than in corresponding segments of *H. nana* or *H. nana fraterna.*

In a mature segment (Fig. 3) the most conspicuous organ is the ovary, which is large and compact, rather irregularly but not very deeply lobed, and occupies roughly one-third of the width of the segment, having a greatest diameter (from side to side) of about 0·15 to 0·17 mm. The ovarian ova have a diameter of 0·015 mm. The yolk-gland and shell-gland lie in the usual

positions with regard to the ovary. The three testes are relatively much smaller than in *H. nana* and *H. nana fraterna*, and, instead of being almost equal in diameter to the antero-posterior length of the segment, they occupy only a small space close to its posterior border. They are generally more oval in shape than those of the other species, which are almost spherical. Their greatest diameter varies from 0·05 to 0·075 mm. The middle testis varies

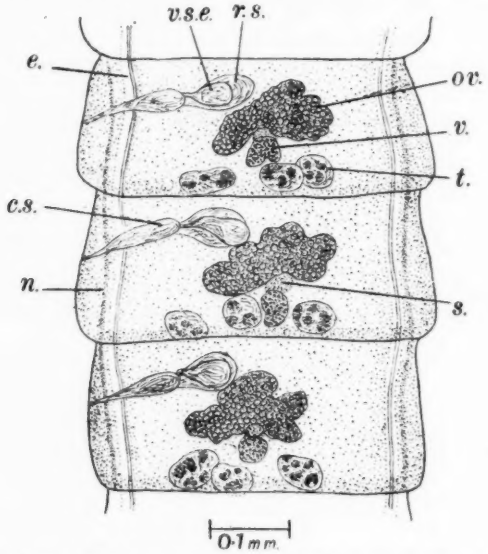


Fig. 3. *Hymenolepis longior.* Three mature segments; dorsal view. (From a whole preparation.) *c.s.*, cirrus-sac, with contained internal seminal vesicle; *e.*, excretory canals; *n.*, longitudinal nerve; *ov.*, ovary; *r.s.*, receptaculum seminis; *s.*, shell-gland; *t.*, testis; *v.*, vitelline gland; *v.s.e.*, external seminal vesicle.

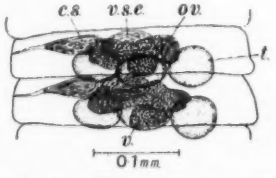


Fig. 4. *Hymenolepis nana fraterna.* Two mature segments; dorsal view. (From a whole preparation.) Lettering as in Fig. 3.

in position with regard to the yolk-gland, and may lie dorsally to it or on either side of it. In the other species it seems to be always in the centre of the segment and dorsal to the yolk-gland. The genital pore is situated at about the middle of the lateral border of the segment, or very slightly in front of it. The cirrus-sac, which measures about 0·15 mm. in length, passes, as usual in *Hymenolepis*, dorsally to both the longitudinal excretory vessels and to the

longitudinal nerve. It is club-shaped, as in the other species, and expands towards its inner end to a maximum width of 0·025–0·03 mm. It is almost completely filled by the internal seminal vesicle. There is also a pear-shaped external seminal vesicle (Fig. 3, *v.s.e.*), which occupies the space between the inner end of the cirrus-sac and the ovary. Ventrally to this lies a large receptaculum seminis (Fig. 3, *r.s.*), being the expanded inner end of the vagina, which runs along the ventral side of the cirrus-sac.

The passage from mature to gravid segments is very gradual. The latter are almost completely filled by the sac-like uterus, which contains a large number of ova. These have a thin outer membrane and a thicker, chitinised inner shell, between which there is a rather deeply-staining granular material which sometimes appears to form a third "membrane." The inner shell is distinctly lemon-shaped, as opposed to the almost spherical inner shell of *H. nana* and *H. nana fraterna*, and it possesses at or near each pole a well-developed thickening. The terminal filaments present in the other species appear to be absent. Measurements taken by Mr Dudgeon and Dr A. C. Stevenson from ova in a fresh state in the faeces of infected rats were as follows: outer membrane, 49–60 μ × 42–48 μ; inner shell, 28·5–35·25 μ × 22·5–28·5 μ; the knobs at the poles measure 2–4 μ; onchosphere, 24–35 μ × 21–27 μ; length of embryonic hooks, 10·5–15 μ.

The following table of measurements and other data taken from Mr Dudgeon's material will help to bring out some of the differences between *H. nana fraterna* and the new species.

	H. nana fraterna	*H. longior*
Total length	Up to 20 mm.	Up to 45 mm. (60 mm. if stretched)
Width of strobila (max.)	0·27—0·51 mm.	0·42—0·53 mm. (0·65 mm. if contracted)
Width of scolex (great variation according to degree of contraction)	0·16—0·23 mm. Mean about 0·19 mm.	0·21—0·26 mm. Mean about 0·24 mm.
Suckers, outside diameter	0·05—0·07 mm.	0·075—0·093 mm.
Rostellum, diameter	0·05—0·07 mm.	0·07—0·08 mm.
Number of hooks	22—26 (usually 22 or 23)	21—22 (usually 22)
Length of hooks	16—18μ	19—20μ
Number of segments	Up to 250	Up to, or over, 600
Segment at which rudiments of genital organs begin to appear (roughly)	35th	50th
Segment at which mature genital organs appear (roughly)	75th	250th
Number of gravid segments (roughly)	20—70	60—100
Ova, diameter of outer membrane[1]	67·5—90μ × 66—87μ	49—60μ × 42—48μ
Ova, diameter of inner shell[1]	40·5—51μ × 36—43·5μ	28·5—35·25μ × 22·5—28·5μ
Ova, diameter of onchosphere[1]	36—45μ × 31·5—40·5μ	24—35μ × 21—27μ
Embryonic hooks, length	15μ	10·5—15μ

[1] These measurements were taken by Mr Dudgeon and Dr Stevenson from fresh ova in the faeces of rats.

Many authors have given measurements of *Hymenolepis nana* and "*H. murina*," and it appears to the writer that, among the individuals ascribed to the latter form, some in reality belonging to the species now described as new have frequently been included. The new species appears, in fact, to have been confused with "*H. murina*" ever since the original description of the latter by Dujardin (1845), and to have been responsible for some of the alleged differences between it and the *H. nana* of man. The discrepancies in the measurements of total length given by different writers for "*H. murina*" are greater than could readily be accounted for by different states of contraction in complete individuals of the same species. 25 mm. is given by several authors as the maximum for *H. nana*, whereas "*H. murina*" is frequently said to reach 40 or 45 mm.—the latter figure agreeing with that given above for *H. longior*. According to Mr Dudgeon's material, *H. nana fraterna* (the true "*H. murina*") rarely exceeds 20 mm. in length, unless abnormally stretched. Other measurements, such as those of the maximum width of the strobila, the width of the scolex, and the diameter of the suckers, are so variable that little reliance can be placed upon them. They are certainly, as Joyeux (1919) has pointed out, useless as criteria for distinguishing *H. nana* from *H. nana fraterna*; and they seem to afford as little help in separating *H. nana fraterna* from *H. longior*. It may be mentioned that some of the extreme measurements given by previous writers, especially for the width of the strobila and the diameter of the suckers, find no parallel among the present material. Thus the width of *H. nana* has been recorded as reaching 0·7 mm., and that of "*H. murina*" 0·9 mm. Similarly the diameter of the suckers in *H. nana* is said to be sometimes as much as 0·105 mm. Reference to the table given above will show that nothing approaching these figures has been observed among Mr Dudgeon's material, and it may be suspected that some of them, at least, are erroneous, or due to excessive artificial pressure on the specimens. Much, of course, depends upon technique in handling soft-bodied worms, and for this reason the value of such measurements is often questionable.

In the present case there is one character, depending only in part on measurements, which seems to be of great importance. The inner shell of the egg, being composed of a relatively hard, chitinoid substance, is not subject to alteration by pressure or the action of reagents to the same extent as the soft parts. It has been repeatedly insisted upon that the inner shell of the egg of "*H. murina*" is lemon-shaped, and provided at each pole with a well-developed knob-like thickening; whereas in the egg of *H. nana* the inner shell is more rounded, with the polar knobs scarcely distinguishable, but with a filamentous process at each pole. Unfortunately the measurements of the inner shell have seldom been given. Von Linstow (1896) gives the following:

nana: 0·028 mm. (exceptionally 0·029 × 0·024 mm.), usually spherical.
murina: 0·031 × 0·023 mm., lemon-shaped, with knobs at the poles.

The lemon-shaped inner shell, with polar knobs, is highly characteristic

of the ova of *H. longior*, and it seems almost certain that those authors who have laid stress upon this feature in their descriptions of "*H. murina*"—among them Dujardin himself—were dealing, as regards the ova, with *H. longior*.

There remains one point of considerable interest to be mentioned. As is well known, the researches of Grassi and his collaborators have led to a general acceptance of the theory that *H. nana* (and this covers also "*H. murina*") normally passes through the whole of its life-history in the intestine of the same host, its cysticercoid living in the villi of the small intestine, and not requiring an intermediate host. Nicoll and Minchin (1911) found in the body-cavity of one of the fleas that infest rats in this country (*Ceratophyllus fasciatus*) a cysticercoid, of which they observe that, unless it is that of "*H. murina*," it must be that of some undescribed form, the scolex of which is indistinguishable from that of "*H. murina*." Johnston (1913) also found a cysticercoid in Australia in *Ceratophyllus fasciatus* and another rat-flea, *Xenopsylla cheopis*, which he regarded as that of "*H. murina*." Now it seems highly probable, bearing in mind the great similarity between the scolices of *H. nana fraterna* and *H. longior*, that the latter is the adult form into which this cysticercoid develops, and that these cases cannot be taken as evidence that *H. nana fraterna* ever makes use of fleas as intermediate hosts.

The following species of *Hymenolepis* are recorded in Muridae[1]:

	Hosts
With armed scolex:	
nana fraterna Stiles, 1906 (=*Taenia murina* Duj., 1845, *c.p.*)	*Epimys rattus* *E. norvegicus* *E. alexandrinus* *Mus musculus* *M. pumilis* *Micromys minutus* *Eliomys quercinus*
microstoma (Duj., 1845)	*Epimys rattus* *E. norvegicus* *Mus musculus*
contracta Janicki, 1904	*Epimys norvegicus* *Mus musculus*
criceti Janicki, 1904	*Cricetus cricetus* (*C. vulgaris*)
muris-variegati Janicki, 1904	*Mus variegatus*
longior, sp. n.	*Epimys rattus* *E. norvegicus*
With unarmed scolex:	
diminuta (Rud., 1819)	*Epimys rattus* *E. norvegicus* *E. alexandrinus* *Mus musculus* *Hesperomys pyrrhorhinus*
relicta (Zschokke, 1888)	*Epimys norvegicus* ? *Mus musculus*
horrida (v. Linst., 1900)	*Epimys norvegicus*
procera Janicki, 1904	*Arvicola amphibius*
Scolex undescribed:	
asymmetrica Janicki, 1904	*Microtus arvalis*
crassa Janicki, 1904	*Epimys norvegicus* *Mus musculus*

[1] The descriptions of *H. arvicolina*, *H. diminutoides* and *H. inexspectata* Cholodkovsky, 1912, have unfortunately proved inaccessible. The first appears to occur in *Microtus arvalis* (*Arvicola campestris*), the two last in *Epimys norvegicus*.

REFERENCES.

DUJARDIN, F. (1845). *Histoire naturelle des Helminthes.* Paris.

GRASSI, B. (1887) (*a*). Die *Taenia nana* und ihre medicinische Bedeutung. *Centralbl. f. Bakt.* I. 4. 97.

GRASSI, B. and CALANDRUCCIO, S. (1887) (*b*). Einige weitere Nachrichten über die *Taenia nana*. *Ib.* II. 10. 282.

GRASSI, B. (1887) (*c*). Entwicklungscyclus der *Taenia nana*. *Ib.* II. 11. 305.

GRASSI, B. and ROVELLI, G. (1889). Embryologische Forschungen an Cestoden. *Ib.* V. 11, 12. 370, 401.

—— (1892). Ricerche embriologiche sui Cestodi. *Atti Acc. Gioenia Sci. Nat. Catania* (4), IV. 15.

JOHNSTON, T. H. (1913). Notes on some Entozoa. *Proc. Roy. Soc. Queensland*, XXIV. 63.

JOYEUX, CH. (1919). *Hymenolepis nana* (v. Siebold, 1852) et *Hym. nana* var. *fraterna* Stiles, 1906. *Bull. Soc. Path. exot.* Paris, XII. 5. 228.

LINSTOW, O. VON (1896). Ueber *Taenia* (*Hymenolepis*) *nana* v. Siebold und *murina* Duj. *Jena. Zeitschr.* XXX. 571.

NICOLL, W. and MINCHIN, E. A. (1911). Two species of Cysticercoids from the rat-flea (*Ceratophyllus fasciatus*). *Proc. Zool. Soc.* 9.

STILES, C. W. (1906). Illustrated Key to the Cestode Parasites of Man. *Bull.* 25, *Hyg. Lab. U.S. Pub. Health and Mar.-Hosp. Serv.* Washington.

ADDENDUM.

Since the preparation of the paper on *Hymenolepis* from rats, the author has seen descriptions of *H. diminutoides*, *H. inexspectata* and *H. arvicolina* given by Cholodkovsky in *Ann. Mus. Zool. Ac. Sci.*, Petrograd, XVIII. (1913), pp. 227–229. Although the names are here marked "spec. nova," they appear to have been first published in a catalogue of parasitic worms of the Army Medical Academy of Petrograd, in the previous year. It is this publication which was referred to as inaccessible, the redescriptions of 1913 having escaped notice.

H. diminutoides and *H. arvicolina* belong to the unarmed group of species. The description of *H. inexspectata* is very brief, and scarcely suffices to determine whether this species is distinct from that described by the writer as *H. longior*. The number and size of the hooks, the size of the suckers and the arrangement of the testes, as described, indicate differences which may be of specific importance, but the other differences are such as to be accounted for by a greater degree of muscular contraction, and it is impossible to lay any stress upon them.

H. diminutoides is recorded from *Microtus arvalis* (*Arvicola campestris*) as well as from the brown rat. *H. straminea* (Goeze, 1782), from *Cricetus cricetus*, should be added to the list of forms with armed scolex.

NOTE ON THE HABITAT AND STRUCTURE OF *CRASSICAUDA* [NEMATODA].

By H. A. BAYLIS, M.A., D.Sc.

(*Published by permission of the Trustees of the British Museum.*)

(With 3 Text-figures.)

Complete specimens of this nematode are difficult to obtain, owing to the manner in which the worms bury themselves in the tissues of the urinogenital system of the Cetacea in which they are found. Mr A. G. Bennett, to whom the writer has previously been indebted on more than one occasion for *Crassicauda* material, has recently sent home further interesting specimens from South Georgia, accompanied by notes and a sketch which throw some light upon the burrowing habits of the worm. A special effort was made to obtain complete specimens by dissection.

In a previous note, in which an attempt was made to collect the records of the occurrence of this remarkable genus, the writer (1916) quoted an interesting passage from a report by Mr J. E. Hamilton, on the formation of "connective tissue masses" by the worms in the kidneys of *Balaenoptera physalus*. From Mr Bennett's observations it appears that "masses" or nodules of a similar nature may also be formed in other tissues. The accompanying diagram, which is adapted from Mr Bennett's drawing, shows the course taken by one of the worms in the tissues of the penis of a *Balaenoptera* (probably *B. physalus*). The caudal end of the worm hangs freely in the lumen of the urethra, through a perforation in the wall of which its body passes into the dense surrounding tissue. Through the kindness of Mr R. H. Burne, the writer has been enabled to compare Mr Bennett's sketch with a preparation of the penis of a *Balaenoptera* in the Museum of the Royal College of Surgeons. This makes it clear that the actual tissue invaded by the parasite is the dense fibrous sheath of the corpus cavernosum.

According to Mr Bennett's notes, the free portion of the worms varied from two to four inches in length. After traversing the fibrous tissue for some distance, the body passes into a dense nodule (A), where it becomes flattened and much coiled. The substance surrounding the worm in this nodule is in some cases putty-like, in others hard and apparently calcareous. The worm may be traced on again beyond this nodule for a longer or shorter distance, but eventually it passes into a second nodule (B) of pus and fibrous

tissue, in which the head is found. It is easy, therefore, to understand the difficulty hitherto experienced in obtaining an unbroken specimen of *Crassicauda*. The nodules, formed in the dense tissue of the penis or in other solid tissues, effectually prevent it from being pulled out; while its tortuous course renders the task of dissecting out the worm, without cutting it, a very difficult one, especially if the surrounding tissue has been hardened by reagents.

Mr Bennett succeeded, by cutting out one of the hard nodules (A) with the worm, in extracting the latter entire, and on examination it proved to be a male *C. crassicauda* (Crepl.). Anterior portions of females, almost certainly of the same species, were also obtained. This material enables some further details to be added to the description of *C. crassicauda*. The writer (1916,

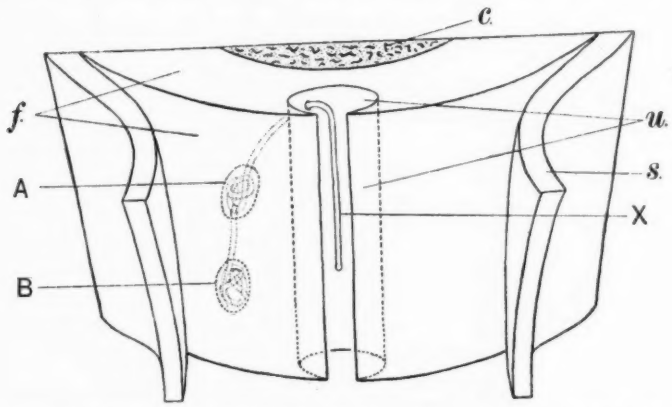


Fig. 1. Diagram, adapted from a drawing by Mr Bennett, of an excised portion of the penis of *Balaenoptera*, with a specimen of *Crassicauda crassicauda in situ*. The upper part of the drawing is in transverse section. In the lower part, the skin has been cut longitudinally over the urethra and reflected on either side. The urethra is represented as slit open longitudinally. *c.*, cavernus core of corpus cavernosum; *f.*, fibrous sheath of corpus cavernosum; *s.*, skin of penis; *u.*, urethra; *X*, caudal end of worm hanging freely in urethra; *A*, *B*, successive nodules formed by the worm.

1920) has published some notes on the anatomy, but the characters of the anterior end were still very imperfectly known. The cephalic papillae of a specimen thought to be *C. crassicauda* were described in the former paper, but in the second it was shown that at least two species exist, and this rendered the conclusions of the first less certain. In the light of the material now received, which is proved by the characters of the male tail to be *C. crassicauda*, it is possible to say that the characters of the head previously described agree with those of *C. crassicauda*. It is not, of course, possible to say whether they differ from those of *C. boopis*, which is only certainly known from headless specimens. The accompanying figures (Figs. 2 and 3) show that the same papillae are present, and that they are arranged in the same way, as in the head of which an "*en face*" view was previously (1916) figured.

The structure of the oesophagus and other organs of the anterior region has not hitherto been described. The mouth, which is laterally compressed, leads into a similarly compressed buccal cavity, with very thick cuticular walls. This is followed by an oesophagus consisting of a relatively short

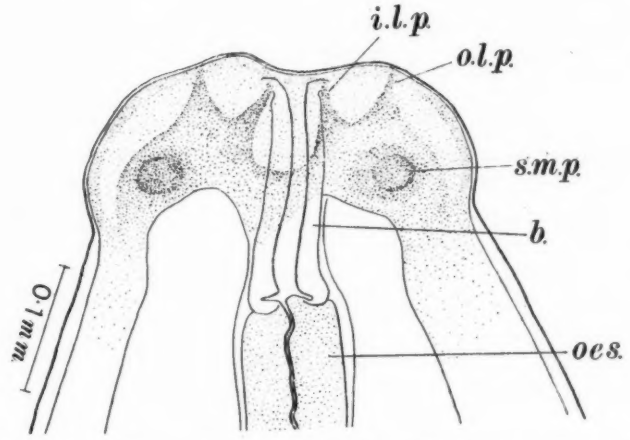


Fig. 2. *Crassicauda crassicauda.* Anterior end of male; dorsal or ventral view. *b.*, wall of buccal cavity; *i.l.p.*, inner lateral papilla; *oes.*, anterior portion of oesophagus; *o.l.p.*, outer lateral papilla; *s.m.p.*, submedian papilla.

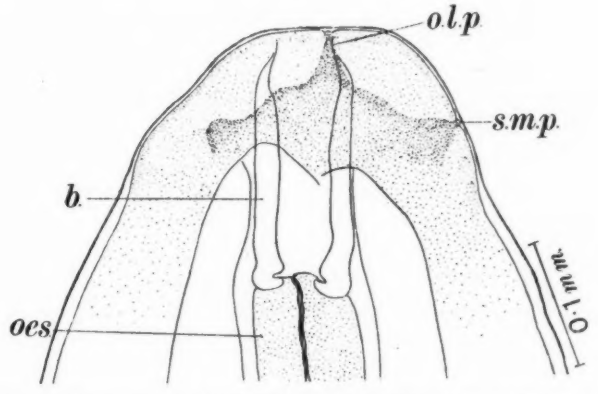


Fig. 3. *Crassicauda crassicauda.* Anterior end of male; lateral view. Lettering as in Fig. 2.

anterior portion, which is scarcely, if at all, muscular, and a very long posterior portion, which is partly muscular and partly glandular. The latter portion may double upon itself several times in its course. An excretory pore has not been detected.

Measurements made from the complete male and an incomplete female were as follows (in millimetres):

	♂	♀
Length of buccal cavity . . .	0·18	0·23
Length of anterior portion of oesophagus	1·85	1·95
Thickness of anterior portion of oesophagus	0·11	0·16
Length of posterior portion of oesophagus	about 25·0	about 31·0
Thickness of posterior portion of oesophagus	0·3—0·4	0·47—0·8
Distance from anterior end to nerve-ring	0·5	0·4 (neck of worm contracted)

The genus *Crassicauda* has hitherto been assigned tentatively to the family Filariidae, but the posterior position of the vulva is a character difficult to reconcile with this arrangement. It may be remarked that in this feature, as well as in the general structure of the oesophagus and buccal cavity, now described for the first time, *Crassicauda* somewhat resembles *Tetrameres* (= *Tropidocerca*, *Tropisurus*), a genus usually included in the Spiruridae, but placed by itself by some authors in a family Tetrameridae. The globular form characteristic of the mature females of *Tetrameres* is not, however, seen in *Crassicauda*.

REFERENCES.

Baylis, H. A. (1916). On *Crassicauda crassicauda* (Crepl.) [Nematoda] and its Hosts. *Ann. and Mag. Nat. Hist.* (8), xvii. 144–148.

—— (1920). Observations on the Genus *Crassicauda*. *Ibid.* (9), v. 410–419.

OCCURRENCE OF *HELIGMOSOMUM BRASILIENSE* TRAV. IN ENGLAND.

By G. C. DUDGEON, C.B.E., F.E.S., etc.

Wellcome Bureau of Scientific Research.

In making the examination of a series of 400 rats, *Heligmosomum brasiliense* was found in 6 per cent. of those examined. The rats were all of the one species, *Epimys norvegicus*, and were chiefly from London and suburbs; the exceptions being one from Berkshire, one from Hampshire and two from Hertfordshire.

The worms are found, generally, in the upper third of the small intestine, and the measurements, where they differ from those previously described for this species, are given.

Male. In all cases, measured, the average length of the male is 2·8 mm. and the width 0·087 mm., giving a mean ratio of 32 : 1. The spicule averages 0·561 mm. The lobes of the bursa are asymmetrical in form; the latero-ventral and externo-lateral rays of the left lobe run parallel, and generally contiguous, throughout their length. The right lobe is much thickened and normally enrolled into a bar. The dorsal lobe is short and bears three rays, the central one terminating in two branches, which are again divided, the inner digitation bearing a small node on its outer edge, the outer digitations being slightly curved outwardly.

Female. The female averages 3·7 mm., with a thickness of 0·106 mm., giving a mean ratio of 34 : 1.

The worm has 14 longitudinal ridges visible in the median section; those of the lateral area are deeper and more prominent than either the dorsal or ventral ones. These ridges diminish in number towards the anterior end, and appear to be all present posteriorly, but of more uniform and much reduced dimensions.

A comparison of the measurements of British with those of Australian specimens may be of interest: *Heligmosomum brasiliense* Trav. was described and figured by T. Harvey Johnston, M.A., etc., in the *Proceedings of the Royal Society of Queensland*, vol. xxx. p. 56, for 1918, but with some rather remarkable differences in measurement. The general form of the worms from both continents is the same.

AN INTERESTING CASE OF *CYSTICERCUS FASCIOLARIS* INFESTING THE BROWN RAT.

By A. T. HOPWOOD,

Assistant in Zoology, West Virginia University, Morgantown, W. Va.

(With Plate I.)

Cysticercus fasciolaris, the larval stage of the common tapeworm *Taenia taeniaeformis* (*T. crassicolis*), was recently found in great numbers in the liver of a brown rat. The rat measured 18 cm. in length and weighed about 275 g.; it was vigorous and apparently healthy when caught, but when killed and examined, its liver was found to be heavily infested with the cysticerci.

This cestode in itself is common enough, but the great number of cysticerci attracted attention. On the ventral surfaces of the ventral lobes of the liver which are shown in the photograph (Pl. I), 108 of the cysts were visible and this region was the least infested. The dorsal surfaces of these lobes as well as the entire surfaces of the others harboured cysts almost to their full capacity. It is difficult to conceive how many more of the larvae could possibly have found room to encyst themselves. There was visible a total of 256 larvae, about 50 of which were visible from both surfaces. Many more may have been embedded in the tissue and invisible from either surface.

Possibly not more than nine-tenths of the liver was incapacitated and the bile ducts were not greatly obstructed, which probably explains why the animal was still apparently healthy. The cysticerci were identified in the laboratory and their determination was confirmed by reference to the Zoological Division of the Bureau of Animal Industry of the U. S. Department of Agriculture.

Brown Rat infested by *Cysticercus fasciolaris*.

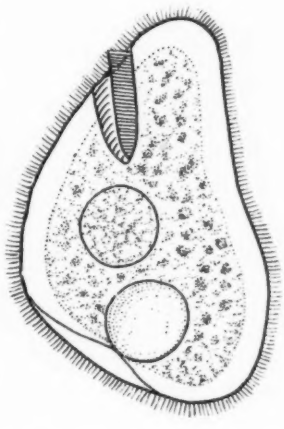
ON A NEW CILIATE, *BALANTIDIUM BLATTARUM*, SP. NOV., INTESTINAL PARASITE IN THE COMMON COCKROACH (*BLATTA AMERICANA*).

By EKENDRANATH GHOSH, M.Sc., M.D.,
Professor of Biology, Medical College, Calcutta.

(With 1 Text-figure.)

The parasite herein described was found in the intestinal contents of *Blatta americana* at Calcutta. The species seems to be comparatively rare and was observed twice only. It may be named *B. blattarum* sp. nov.

Diagnosis: Body irregularly pyriform, slightly less than twice as long as its greatest transverse diameter, and circular in transverse section. Anterior end tapering, rounded and slightly bent to the side opposite to the peristome. Posterior end obliquely truncate and depressed in the middle. Side opposite to the peristome longer than the other, being slightly concave in front and convex behind. Side with the peristome short and convex. Peristome small, about one-third the body in length, somewhat cylindrical and directed backwards and medianwise. A large undulating membrane along the anterior margin of the peristome, and a row of stout cilia along the posterior margin. Body cilia small and arranged closely. Endoplasm coarsely granular and surrounded by a distinct hyaline ectoplasm. Macronucleus spherical, and placed behind the peristome in the middle of the body and somewhat towards the shorter side. A large contractile vacuole posteriorly. Length 0·09 mm. (See Text-fig.)



Balantidium Clap. and Lach., was emended by Bütschli (in Bronns, *Tierreich*, Protozoa, 3 Abt., pp. 1723–1725), by the removal of two species (*B. duodeni* and *B. rotundum*) which were placed together in a separate genus: *Balantidiopsis*. He characterised *Balantidium* by its round transverse section and its habitat in the large intestine, and *Balantidiopsis* by its flattened body and its habitat in the small intestine.

Scheier (*Arb. d. St Petersburger naturf. Gesellsch.* XXVIII. No. 4) defines the two genera in the following manner: *Balantidium:* body egg-shaped or cylindrical; contractile vacuoles numerous; macronucleus oval or horseshoe-shaped. *Balantidiopsis:* body broadly oval; contractile vacuole single, posterior; macronucleus spherical.

This year I described two new species of *Balantidium* and *Balantidiopsis* (*Bull. Carmichael Med. College*, No. 2) to which I appended synopses of the known species of both the genera. But the recognition of a large number of species of both the genera has made all the distinguishing characters fail one after another, viz. the number of contractile vacuoles, the form of the macronucleus and the nature of the habitat. Lastly, the discovery of species with oval transverse section of the body breaks the last distinction between the two genera. Under these circumstances it seems necessary to reunite the two genera into *Balantidium* as already suggested by Bezzenberger (*Arch. f. Protistenk.* III. 154–156).

As regards habitat, the already known species of *Balantidium* have been found in the gastric cavity of *Hydra* (*B. hydrae*, Entz, *Arch. f. Protistenk.* 1912, XXVII.) and medusa, and in the intestinal canal of the mollusc and of many vertebrates, specially the amphibians. The present species seems to be the first described from the intestinal tract of an arthropod.

SOME OBSERVATIONS ON THE BIOLOGY AND STRUCTURE OF *ORNITHODORUS SAVIGNYI*, ANDOUIN.

By NORMAN CUNLIFFE, M.A. (Cantab.).

Christopher Welch Lecturer in Economic Zoology, University of Oxford, and formerly Student in Medical Entomology, Quick Laboratory, Cambridge.

(With 3 Text-figures.)

CONTENTS.

	PAGE
Introduction	17
Section I. Biology of *O. savignyi*	18
Experimental records relating to females kept at different temperatures	18
Oviposition	20
No evidence of parthenogenesis	20
Longevity of female tick	20
Duration and number of nymphal stages at 30° and 37° C.	21
(*a*) Experimental data	21
(*b*) Discussion of data	21
Duration and extent of engorgement	22
The influence of moisture on vitality and ecdysis	22
Section II. Structure of *O. savignyi*	23
Dimensions of egg	23
Dimensions of unfed stages	23
Changes in external anatomy undergone during development (*a*) hypostome, (*b*) leg and spiracle	24

INTRODUCTION.

Some observations on the biology and structure of *Ornithodorus moubata* have been recorded in a recent communication to this journal (Cunliffe, 1921) and in the following pages all references to this species refer to these observations, unless otherwise stated. Prof. Nuttall received living material of *O. savignyi* from Dr J. H. Ashworth in 1911 (from Aden, *Quick Lab. Cat. No.* 1575) and again in 1913 (no data, *Cat. No.* 2011). These stocks being available for breeding experiments, a few observations on the biology and structure of this species were made in the years 1913–14.

Even at the present time, details of the life-cycle of *O. savignyi* appear to be unknown. Howlett (1916) and Fletcher (1919) have both stated that this

tick was being studied at Pusa, but their results are apparently as yet unpublished. Nuttall and Warburton (1908) only note that "there are at least two nymphal stages, if not more." These facts and also that *O. savignyi* is a potential disease carrier justify the publication of these incomplete notes, made under laboratory conditions. This investigation did not yield the same amount of information as was obtained in the case of *O. moubata*, as the two were run together, and it was not possible to rear successfully large numbers of individuals of both species. As would be expected, the results of this second investigation are, for the most part, in agreement with those of the first, and where confirmation is complete, discussion of the records is omitted for economy of space, the reader being referred to the paper on *O. moubata*.

SECTION I. BIOLOGY OF *O. SAVIGNYI*.

It is unnecessary to recapitulate the experimental procedure, which was the same throughout as that adopted for *O. moubata*. Similar also was the aim of the investigation, namely, the determination of the number of nymphal stages passed through by this tick before reaching maturity, of the effect of temperature and moisture on the duration of the stages and of the changes taking place in the external anatomy of the ticks at each stage of development. As before, some notes were made on oviposition, copulation, longevity and engorgement. Females, with their progeny, from each stock were reared separately, but their records, being similar, are not shown separately in the following synopses of results.

Experimental records relating to females kept at different temperatures.

Three series of female ticks were maintained at 22°, 30° and 37° C. respectively, but only the second series bred at all successfully, as shown in Synopsis I.

Females and progeny maintained at 22° C.

A series of six females, which emerged from the last nymphal stage between May and July, 1913, although they fed well and were fecundated on one or more occasions, failed to oviposit until about the 400th day. The larval yield was too small to promise success in rearing and the experiment was discontinued. Females which emerged about the same time from the same stock, reproduced very successfully at 30° C. However, it is considered that a repetition of this experiment would show that 22° C. is not too low a temperature for reproduction by this species.

Synopsis I. *Females and progeny maintained at* 30° C.

Time reckoned in days from date of emergence of female.

No. of ♀	Date of emergence	Times of feeding	♂ added	Copulation observed	Commencement of oviposition after ♂ added	Oviposition: Period of life	Oviposition: No. of eggs	Oviposition: No. of larvae*	Death of ♀
40	20. vii. 13	14	37	37	47	84–85	29	nil	393
—	—	38	—	—	—	105	4	nil	—
—	—	79	—	—	—	135	6	nil	—
—	—	115	—	—	—	148–150	32	nil	—
—	—	172	—	—	—	191–195	77	10	—
—	—	277	—	—	—	295–296	26	17	—
41	26. vi. 13	5	69	70	15	84–85	43	27	412
—	—	69	—	—	—	88	18	11	—
—	—	103	—	—	—	92–94	3	nil	—
—	—	138	—	—	—	123–124	44	30	—
—	—	194	—	—	—	129–130	23	17	—
—	—	301	—	—	—	145	6	5	—
—	—	—	—	—	—	156	3	3	—
—	—	—	—	—	—	212–219	59	49	—
42	26. vi. 13	5	69	—	16	85–94	128	90	—
—	—	69	—	—	—	120	20	15	—
—	—	103	—	—	—	125–126	25	11	—
—	—	139	—	—	—	155–158	80	49	—
—	—	196	—	—	—	229	4	nil	—
—	—	298	—	—	—	—	—	—	—
43	23. vi. 13	2	74	74	20	94	8	6	420
—	—	72	—	—	—	97	10	8	—
—	—	106	—	—	—	100	9	9	—
—	—	144	—	—	—	128	29	25	—
—	—	197	—	—	—	134–136	58	37	—
—	—	303	—	—	—	165–166	45	21	—
—	—	—	—	—	—	182	10	nil	—
—	—	—	—	—	—	229	10	nil	—
44	20. v. 13	17	103	104	17	120–124	68	47	249
—	—	103	—	—	—	155–157	21	7	—
—	—	137	—	—	—	165	2	nil	—
—	—	175	—	—	—	189	9	nil	—
—	—	228	—	—	—	—	—	—	—
16	25. iii. 13	24	19	20	20	49–50	89	77	242
—	—	78	—	—	—	90	25	17	—
—	—	155	—	—	—	—	—	—	—
—	—	196	—	—	—	—	—	—	—
—	—	234	—	—	—	—	—	—	—
17	20. iii. 13	29	37	37	17	54–55	82	65	396
—	—	55	—	92	—	67	48	38	—
—	—	160	—	—	—	69–72	64	46	—
—	—	201	—	—	—	75	3	nil	—
—	—	295	—	—	—	95–96	46	43	—
—	—	—	—	—	—	101	13	13	—
—	—	—	—	—	—	179–180	91	76	—
—	—	—	—	—	—	214	16	11	—
—	—	—	—	—	—	251–252	39	32	—
—	—	—	—	—	—	264	15	7	—
18	25. iii. 13	24	24	25	16	40–41	55	41	394
—	—	50	—	108	—	49–50	62	57	—
—	—	78	—	—	—	60–61	76	42	—
—	—	155	—	—	—	65	34	12	—
—	—	196	—	—	—	67	20	12	—
—	—	203	—	—	—	96	26	12	—
—	—	290	—	—	—	118	8	nil	—
—	—	—	—	—	—	173	19	14	—
—	—	—	—	—	—	207	11	nil	—

* The subsequent history of these larvae is summarised in Synopsis II.

Females and progeny maintained at 37° C.

Two separate series of females were maintained at this temperature, the first set being started in November 1912, and the second in July 1913. Out of a total of 11 females only four oviposited, the records being as follows: ♀ 1, 92 eggs after 19–28 days (from date of emergence) followed by 14 eggs after 69 days; ♀ 2, 100 eggs after 16–17 days; ♀ 3, 8 eggs after 46 days followed by 56 eggs after 78–86 days; ♀ 4, 71 eggs after 69–74 days. These females were fed for another six months without further oviposition taking place and they were then discarded. Larvae emerged from 65 per cent. of the eggs, but reference to Synopsis II, in which their subsequent history is summarised, will show that none of them succeeded in passing the third nymphal stage at this temperature.

Oviposition.

When first deposited the egg is yellow in colour; it rapidly turns brown, more slowly becomes pitchy-brown and finally, in the course of three or four days, becomes jet-black. The agglutinative coating soon loses its efficacy in this species. The data, relating to oviposition, are summarised in the following table, minimum, maximum and mean results being shown:

	Ticks maintained at 30° C.		
	Minimum	Maximum	Mean
No. of days before oviposition occurred after ♂ was allowed access to ♀	15	20 (aberrant case 47)	17
No. of eggs deposited after each feed (when oviposition occurred)	4	174	62
No. of days between dates of feeding and oviposition commencing or recommencing	5	35	18
No. of days over which oviposition extended after each feed	1	50	9
No. of eggs deposited by a ♀	100	417	219
Percentage of fertile eggs		62 %	

The mean results are very closely comparable with those obtained in the case of *O. moubata* (at 30° C.), except that the number of eggs oviposited by the female is less by 40 per cent.

No evidence of parthenogenesis.

Parthenogenetic reproduction did not occur during the course of these experiments. Virgin females, which emerged in October 1913, were fed repeatedly, and maintained at 30° C. between meals, but they failed to oviposit during the following eight months. On the other hand, it has been shown that gorged females oviposit regularly about 17 days after the males are allowed access to them (at 30° C.).

Longevity of the female tick.

When performing their normal functions and maintained at 30° C., seven females lived for minimum, maximum and mean periods of 292, 420 and 358 days respectively. Under similar conditions at 22° C., the female had an average life of 775 days (three individuals).

Duration and number of the nymphal stages at 30° *and* 37° C.

(*a*) Experimental Data.

Some of the progeny of each female were reared in separate batches to the adult stage, to establish the duration and number of the nymphal stages. The records are summarised in Synopsis II, minimum, maximum and mean periods, together with the numbers of individuals observed, being given. As in *O. moubata*, the larva[1] passes into the first nymphal stage without previous engorgement; from the first nymphal stage onwards, the periods required for ecdysis are reckoned from the date of the previous meal and not that of the previous moult.

Synopsis II. *Duration of stages in days.*

	Ticks kept at 30° C.				Ticks kept at 37° C.			
Stage	Min.	Max.	Mean	No. of individuals observed	Min.	Max.	Mean	No. of individuals observed
Egg to larva	7	28	12	709	7	11	8	231
Egg to 1st ⊙	13	32	19	630	11	20	15	198
1st to 2nd ⊙	8	30	11	348	5	11	8	121
2nd to 3rd ⊙	9	18	12	184	7	11	8	8*
3rd to 4th ⊙ or adult	⊙ 7	49	14	116				
	♂ 21	33	29	3†				
4th to 5th ⊙ or adult	⊙ 11	25	15	63				
	♂ 13	22	17	29				
	♀ 16	20	17	6				
5th to 6th ⊙ or adult	⊙ 15	26	17	6				
	♂ 14	23	18	14				
	♀ 15	19	17	12				
6th to 7th ⊙ or adult	⊙	No record						
	♀ 15	—	15	2				

* These eight individuals were the only survivors out of 121 second stage nymphs and as third stage nymphs they refused to feed.

† Probably abnormal.

(*b*) Discussion of Data.

As with *O. moubata*, males appeared after four to six and females after five to seven ecdyses, 63 per cent. of the males appearing after the fifth ecdysis and 60 per cent. of the females after the sixth ecdysis. As, however, only 66 individuals were reared to maturity, these percentages may require correction. The mean minimum periods required for the metamorphosis of an individual from egg to adult, at 30° C., under laboratory conditions, are

(1) for males, 60 (*corrected*), 73 or 89 days according to whether the individual undergoes four, five or six moults;

(2) for females, 73, 88 or 103 days, the number of moults varying from five to seven.

These periods are longer by an average of 27 days than in the case of

[1] The larva normally frees itself from the egg shell, but is otherwise inactive. In some cases, however, the species approaches *O. moubata*, inasmuch as the larva may undergo ecdysis without throwing off the shell. The feeble development of the hypostome, legs and claws and also the absence of eyes is doubtless correlated with the passiveness of this stage.

O. moubata, reared under similar conditions. An increase in temperature of 7° C. (from 30° C.) only reduced the period required for the production of third stage nymphs by 26 per cent.

Duration and extent of engorgement.

An experiment, similar to that carried out with *O. moubata*, was conducted with this species, ten nymphs of different stages being kept under observation until they reached maturity. Their weights before and after engorgement and the times of attachment to the host were accurately recorded. Again there was no regularity in the time of attachment, observation on 29 individuals of all stages giving minimum, maximum and mean times of 10, 74 and 26 minutes respectively, at room temperature, about 16° C. The figures are in agreement with those of Drake-Brockman (1915). The mean time recorded for *O. moubata* was 48 minutes, thus *O. savignyi* is apparently a more rapid feeder. Of the ten nymphs under observation, only four reached maturity, one being male and three female. In the female series, the mean increase in weight in grams was (*a*) before the final moult, 0·0647, and (*b*) after the moult 0·2202; the corresponding figures for the solitary male were (*a*) 0·0528, and (*b*) 0·0246. None of these figures were reached by *O. moubata*.

The influence of moisture on vitality and ecdysis.

A similar experiment to that carried out with *O. moubata* proved that, for this species also, excess of moisture is injurious to the individual. A batch of 33 first stage nymphs from the same female was divided into three lots, which between meals were maintained at 30° C. in saturated, moist and dry atmospheres respectively. A summary of the experimental records[1] is given in the following table, in which are shown the minimum and maximum number of days required for ecdysis, with the mean in brackets and the number of individuals observed in square brackets:

Atmosphere	2nd ⊙	3rd ⊙	4th ⊙	5th ⊙	6th ⊙	% of ticks which matured
Saturated	9—13 (11) [11]	11—14 (13) [11]	23—48 (40) [7] 1 ♂	21 [1]	—	9 %
Moist	7—8 (8) [11]	9—32 (12) [11]	10—18 (12) [11] 2 ♂	11—17 (14) [4] 1 ♂	—	27 %
Dry	7—9 (7) [11]	9—13 (10) [8]	11—16 (12) [8] 1 ♂	10—14 (12) [5] 2 ♂, 1 ♀	13—17 (15) [2] 1 ♀	45 %

Excess of moisture was therefore a decidedly unfavourable factor, as under this condition only 9 per cent. of the ticks matured, whereas in the dry atmosphere 45 per cent. matured. The ecdysis period was not markedly affected by the presence of moisture (*vide* Synopsis II), until after the third nymphal stage was attained, when the lack of vitality was indicated by a lengthening of this period.

[1] The 1st nymphs were fed on 17. i. 13 and the 5th nymphs were fed or offered a meal on 13. vi. 13.

SECTION II. STRUCTURE OF *O. SAVIGNYI*.

Observations on the dimensions of the egg and unfed specimens of the different stages and the changes in form undergone during development by the hypostome, the fourth tarsus and the spiracle are included in this section.

Dimensions of the egg.

A total of 179 eggs were measured immediately after deposition by four different females, the minimum, maximim and mean measurements of length × breadth being 1·0 × 0·9, 1·8 × 1·4 and 1·4 × 1·1 mm. respectively. The minimum and mean measurements of the eggs of this species equal the mean and maximum measurements of those of *O. moubata*.

Dimensions of unfed stages.

As no records of the dimensions of the different stages appear in the literature on this species, measurements of material bred under control from one stock are summarised in Synopsis III. The number of individuals preserved was, in several cases, too small to give very accurate results, although as far as possible extreme examples were chosen for preservation.

Synopsis III. *Dimensions of stages.*

Measurements in mm. to nearest tenth, from unfed specimens preserved shortly after emergence in 70 % spirit.

Stage	Min. Length × Breadth	Max. Length × Breadth	Mean Length × Breadth	No. of individuals observed
Larva	1·2 × 1·0	1·5 × 1·2	1·4 × 1·1	52
1st ⊙	1·3 × 1·0	1·8 × 1·4	1·5 × 1·2	107
2nd ⊙	1·5 × 1·1	2·6 × 1·9	2·1 × 1·5	119
3rd ⊙	2·2 × 1·5	3·6 × 2·6	3·0 × 2·1	16
4th ⊙	3·1 × 2·3	5·6 × 3·9	4·4 × 3·1	14
♂ from 3rd ⊙	5·2 × 3·8*	6·0 × 4·3	5·7 × 4·0	3
5th ⊙	3·9 × 2·8	6·5 × 4·6	5·6 × 3·9	7
♂ from 4th ⊙	5·2 × 3·5	6·7 × 4·6	6·0 × 3·9	25
♀ from 4th ⊙	7·0 × 4·9*	7·8 × 5·6	7·4 × 5·2	4
6th ⊙	5·0 × 3·4	8·5 × 5·7	6·7 × 4·8	6
♂ from 5th ⊙	5·8 × 3·8	7·4 × 5·6	6·5 × 4·7	15
♀ from 5th ⊙	6·7 × 4·7	9·2 × 6·7	8·1 × 5·7	14
7th ⊙	—	—	—	—
♀ from 6th ⊙	6·4 × 4·4	9·3 × 6·7	7·8 × 5·5	2

* Probably not true minima.

As in *O. moubata*, there is considerable variation in the size of individuals of any one stage, maximum measurements in one stage exceed minimum measurements in the succeeding stage, and males of any one stage are only slightly larger, whereas females are distinctly larger, than nymphs of the equivalent stage. In *O. moubata*, the greatest growth took place in the second nymphal stage but in this species it would appear to be spread equally over the second and third nymphal stages, the percentage increases in length being 7·3 (larva to 1st ⊙), 40·0, 42·8, 46·7, 27·3, 19·7 (5th to 6th ⊙), while the

corresponding increases in breadth are 9·1, 25·0, 40·0, 47·7, 25·8 and 23·1 per cent. respectively. The percentage increases in length and breadth from nymphal to adult stages correspond closely in both species, *e.g.* the percentage increases in length × breadth in *O. moubata*, from fourth nymph to male, are 32 × 28—while in *O. savignyi*, the increases are 36 per cent. × 26 per cent.

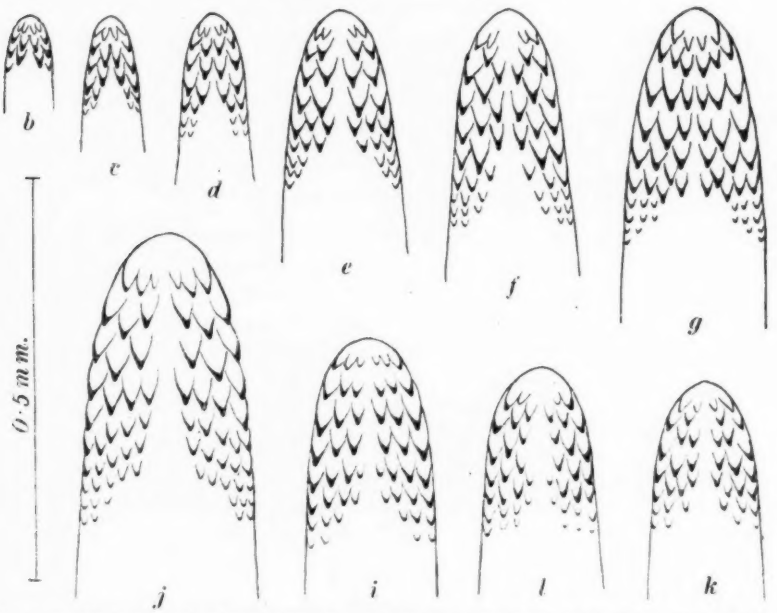


Fig. 1. *Ornithodorus savignyi*, hypostomes in ventral aspect: (*b*) to (*g*) of 1st to 6th stage nymphs; (*i*) and (*j*) of females from 4th and 6th stage nymphs; (*k*) and (*l*) of males from 3rd and 5th stage nymphs. (N. C. del.)

Changes in external anatomy undergone during development.

(*a*) The Hypostome. Fig. 1.

The changes in the dentition of the hypostome during the development from first nymph to adult are indicated in Fig. 1, (*b*) to (*g*) representing the nymphal organs arranged in order of development, (*i*) and (*j*) the hypostomes of females emerging from fourth and sixth nymphs, and (*k*) and (*l*) of males from third and fifth nymphs respectively.

On comparison with the hypostomes of *O. moubata*, it will be observed that in this species also several proximal rows and the distal row of teeth are equally poorly developed and their arrangement difficult to determine, that in the first and second nymphal stages the number and arrangement of the teeth are very similar, but that in the later stages the number of teeth is considerably less, owing to the presence of smaller numbers of rows and files. The changes taking place during development consist of an increasing com-

plexity of dentition, correlated with an increasing size of hypostome and they are of much the same order in both species.

In many cases the teeth are not arranged symmetrically on the two sides of the hypostome, the rows on one side appearing to alternate with the rows on the other side.

(*b*) The Legs and Spiracle. Figs. 2 and 3.

Outlines of the terminal portions of the fourth legs and of the spiracular plates are shown in Figs. 2 and 3 respectively, for the following stages, namely, first to sixth nymph (*a*) to (*f*); males from third and fifth nymphs (*h*) and (*i*); and females from fourth and sixth nymphs (*j*) and (*k*).

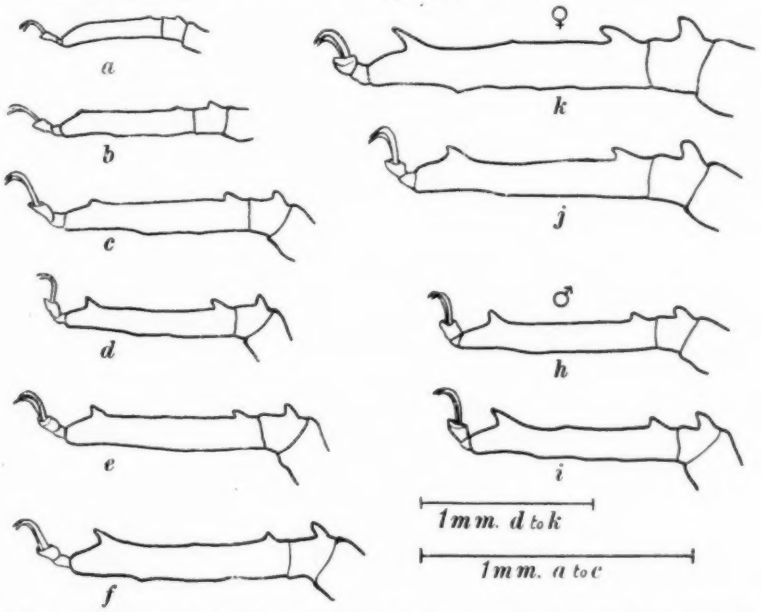


Fig. 2. *Ornithodorus savignyi*, tarsi of fourth legs, in lateral aspect: (*a*) to (*f*) of 1st to 6th stage nymphs; (*h*) and (*i*) of males from 3rd and 5th stage nymphs; (*j*) and (*k*) of females from 4th and 6th stage nymphs. (N. C. del.)

The degree of development of these structures at each stage is similar in the two species, *O. savignyi* and *O. moubata* and needs no further discussion.

SUMMARY OF RESULTS.

1. The biology, as studied under laboratory conditions, of *O. savignyi* is very similar to that of *O. moubata*.

2. Females may oviposit over 400 eggs, of which at least 60 per cent. may be fertile; parthenogenesis does not occur.

3. An increase in temperature of 8° C. (from 22° C.) decreases the longevity

of the female from 775 to 358 days, *i.e.* by 45 per cent.; an increase of 7° C. (from 30° C.) reduces the period required for the production of third stage nymphs by 26 per cent. At 30° C., the mean minimum periods required for metamorphosis are 60 days for males and 73 days for females (cf. *O. moubata*, 36 days for males and 45 days for females). Reproduction was inhibited at 37° C.

4. Moisture is an unfavourable factor, decreasing the vitality of the individual at each stage of growth.

5. Changes in external anatomy undergone during development are similar to those already described for *O. moubata*.

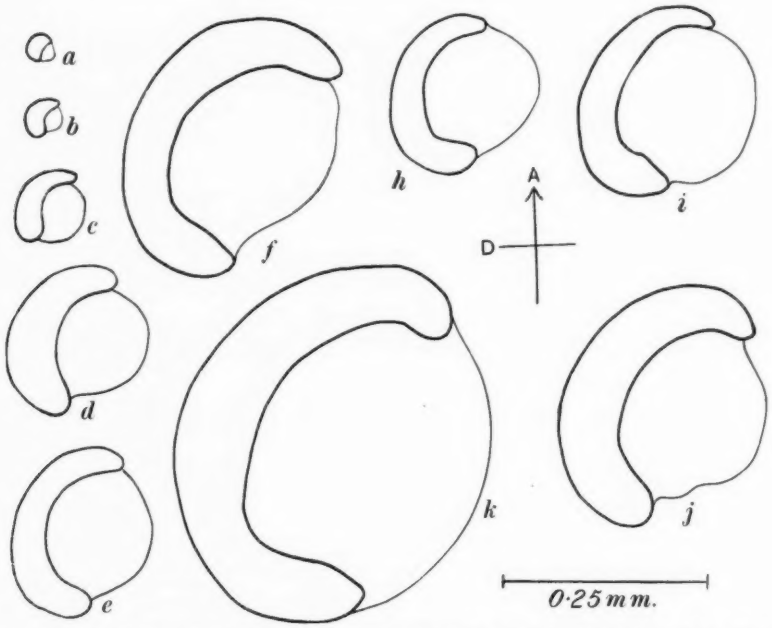


Fig. 3. *Ornithodorus savignyi*, outlines of cribriform plates of spiracles: (*a*) to (*f*) of 1st to 6th stage nymphs; (*h*) and (*i*) of males from 3rd and 5th stage nymphs; (*j*) and (*k*) of females from 4th and 6th stage nymphs. (N. C. del.)

REFERENCES.

CUNLIFFE, N. (1921). Some observations on the biology and structure of *Ornithodorus moubata*, Murray. *Parasitology*, XIII. 327–347.

DRAKE-BROCKMAN, R. E. (1915). Some notes on the Bionomics of *Ornithodorus savignyi* in British Somaliland. *Bull. Entom. Research*, London, VI. 195–196.

FLETCHER, T. B. (1919). *Report of Agric. Research Inst. Pusa*, 1915–16, 78–84.

HOWLETT, F. M. (1916). *Ibid.* 1914–15, 74–77.

NUTTALL, G. H. F. and WARBURTON, C. (1908). *Ticks, a monograph of the Ixodoidea*, Pt. I. Cambridge.

A PRELIMINARY NOTE ON PARASITES INFESTING DOMESTICATED SILVER BLACK FOXES IN CANADA[1].

By J. A. ALLEN, B.V.Sc.,
Animal Pathologist, in charge of Fox Research Station, Charlottetown, P.E.I.

and A. B. WICKWARE, V.S.,
Animal Pathologist, Biological Laboratory, Ottawa, Ont.

(*From the Health of Animals Branch, Dept. of Agriculture, Canada.*)

The growing importance of the silver black fox industry in Canada, and latterly in other countries, has been so marked, that scientific workers have turned their attention to a study of the maladies affecting this species of fox.

A survey has been made by one of the writers (J. A. A.) of the benign and contagious forms of disease to which domesticated foxes are subject, and papers of a popular and scientific nature have already been published in various journals.

In the course of recent investigations dealing with a distemper-like form of disease causing a high mortality amongst foxes, a determination of the species of internal and external parasites was undertaken.

As pointed out by Riley in his recent paper[2], "An Annotated List of the Animal Parasites of Foxes," very little literature is available on this subject, and it is for the purpose of adding a small contribution that the parasites found by us to date are herewith recorded.

We take especial pleasure in acknowledging the courtesy shown by Drs B. H. Ransom, Chief Zoologist, Bureau of Animal Industry, Washington, D.C.; Maurice C. Hall, Senior Zoologist, Washington, D.C.; and F. C. Bishopp, Entomologist, Bureau of Animal Industry, Dallas, Texas, in identifying the listed parasites, and to the various fox ranchers who have provided us with animals for autopsy.

PROTOZOA.

Coccidium bigeminum—Isospora bigemina (Stiles, 1891).
Small and large intestine.

ACARINA.

Sarcoptes scabiei vulpis (Fürstenberg, 1861) Railliet.
Body of host.

Otodectes cynotis (Hering, 1838). Ears of host—external meatus.

[1] Published with the approval of Dr F. Torrance, Veterinary Director General.

[2] Riley, W. A. (III. 1921), *Parasitology*, XIII. 86–96.

SIPHONAPTERA.

Ctenocephalus canis (Curtis, 1826).	Body of host.

NEMATODA.

Eucoleus aerophilum (Creplin, 1839).	Trachea and large bronchi. Eggs found constantly in trachea, oesophagus and faeces.
Belascaris cati (Schrank, 1788) *Belascaris marginata* (Rudolphi, 1802) *Toxascaris limbata* (Railliet and Henry, 1911)	Small intestine.
	Sometimes *B. marginata* penetrates the bile duct and develops in the liver. Immature ascarids found in fox pups less than one week old. Quite common to find intestinal canal from stomach to large colon completely packed with ascarids in young foxes only three to four weeks old. One seldom finds more than one or two ascarids in adult foxes.
Uncinaria polaris (Looss, 1911).	Small intestine.

TREMATODA.

Ascocotyle longa (Ransom, 1920).	Small intestine.
Echinochasmus sp.	Small intestine.

ON THE DIPTEROUS GENERA *PASSEROMYIA* AND *ORNITHOMUSCA*, WITH NOTES AND BIBLIOGRAPHY ON THE NON-PUPIPAROUS MYIODARIA PARASITIC ON BIRDS.

By Professor M. BEZZI, Turin, Italy.

CONTENTS.

		PAGE
I.	*Passeromyia* and *Ornithomusca* . .	29
II.	*Protocalliphora*	32
III.	*Philornis*	36
IV.	*Carnus*	39
V.	*Chortophila* and *Neottiophilum* . .	40
VI.	Conclusions	41
VII.	Bibliography	41

I. *PASSEROMYIA* AND *ORNITHOMUSCA*.

In 1851 Macquart described two new species of the Dipterous genus *Cyrtoneura* from Tasmania, under the names of *Cyrt. longicornis* and *Cyrt. analis*, both species being very different from all others of the same genus in having hairy eyes and the first species also owing to its very long third antennal joint.

They were never recorded by subsequent writers until 1916 when Tyler Townsend describing his new Australian genus *Ornithomusca* expressed doubts as to the relationship of the above mentioned Macquart's species to his own genus (p. 145). In 1919 the late Prof. Stein in his *Catalogue of the Anthomyidae of the World* (p. 111) recorded these two species, showing however that they do not belong to the genus *Muscina* (which now comprises several species of the old genus *Cyrtoneura*) and that they cannot be placed in any known genus of Anthomyidae.

I have recently received from Mr E. W. Ferguson two specimens of a fly, one bred at Sydney, N.S.W., from a larva found in a nestling of the New Holland Honeyeater, the other caught in the open. Both these specimens I have recognised as belonging to the species *Cyrtoneura longicornis* Macquart. On the other hand, the type specimen of *Ornithomusca victoria* Tyler Townsend has been also found in nests of *Pardalotus* sp. and according to the description differ from *longicornis* only in the colour of the dust of the head, palpi, calypters, the base of the wings and the hairs of the body so that it is

very probable that the names *Cyrt. longicornis* and *Orn. victoria* are synonymous[1].

The habit of the above-named Australian fly *Cyrt. longicornis* living upon the bird nestlings recalls that of the African species belonging to the recently established genus *Passeromyia*, and the comparative study of the specimens of the Australian and African forms shows that they are very closely allied. The wide distribution of the African species indicates moreover the importance of a careful study of specimens of this species from the Oriental region. In fact, to this group belongs the species *Muscina longicornis* from Java, previously described by Stein (1909, p. 221). He noticed in this species the elongated third antennal joint, but has overlooked the hairiness of the eyes. In 1915 Dr Villeneuve described under the name *Muscina heterochaeta* a new African fly showing aberrant characters. The larvae of this fly have been previously described by Rodhain (1914, p. 214). The same year (1915) Rodhain and Villeneuve established for this African species the new genus *Passeromyia* and in 1916 appeared a very important paper by Rodhain and Bequaert on the structure and life-history of this fly (*Passeromyia heterochaeta*).

Professor Stein in a recent letter (1920) informed me that the specimens of *Passeromyia heterochaeta* sent to him by Dr Villeneuve, are identical with his paratypes of *Muscina longicornis*. I was able myself to compare the paratype of *longicornis* of my collection with Australian specimens and found that they were strictly congeneric; it is even a matter of some difficulty to distinguish the Australian species from the African. It can be concluded now that the genus *Ornithomusca* Tyler Townsend 1916 is synonymous with the genus *Passeromyia* Rodhain and Villeneuve 1915, and that the type species *heterochaeta* Villeneuve 1915 is synonymous with *longicornis* Stein 1909. As the last name is already preoccupied by Macquart's species, Villeneuve's name *heterochaeta* must be retained.

The two species of the genus *Passeromyia* can be distinguished as follows:

1 (2). The dust of the entire body, chiefly that of the abdomen of the male, is of a distinct bluish tint; third antennal joint about nine to ten times longer than the second joint, and extending almost to the mouth border; bristles of all femora less numerous, shorter and thinner; hind tibiae shortly ciliated; fourth longitudinal vein with the two portions on either side of the bend, of nearly the same length; average size 7 mm. *longicornis* Macquart.

2 (1). Dust of the body grey or slightly bluish on sides of the abdomen of the male; third antennal joint seven or eight times longer than the second

[1] Another question arises in connection with the species *Cyrtoneura analis* Macquart. This species was described from a type specimen with the second and third joint of antennae missing, and it is therefore not certain that this species belongs to the genus *Ornithomusca*. The description of the abdomen recalls the fly *Synthesiomyia nudiseta* which was originally described as *Cyrtoneura* and which is present even in Australia. The hairy eyes and the black first antennal joint of *analis* do not agree with *nudiseta*. Bigot in 1877 (p. 250) placed the species *analis* in the genus *Graphomyia* but removed it in 1887 (p. 584) to the genus *Dasyphora*.

and not reaching the border of the mouth; bristles of the underside of the femora longer, stronger and more numerous than in previous species; hind tibiae with longer ciliation; the portion of the fourth vein in front of the bend is longer than the hinder portion; average size 8–9 mm.

heterochaeta Villeneuve.

Passeromyia.

Rodhain and Villeneuve, 1915, p. 592; Rodhain and Bequaert, 1916, p. 249.
Ornithomusca, Tyler Townsend, 1916, p. 45.

1. **Passeromyia longicornis** (Macquart).

Cyrtoneura longicornis, Macquart, 1851, p. 228 (255), pl. 23, fig. 8; Stein, 1919, p. 111.

Ornithomusca victoria, Tyler Townsend, 1916, p. 45.

Geographical distribution. Australia; Victoria (in nest of *Pardalotus* sp.); New South Wales, Sydney; Tasmania.

2. **Passeromyia heterochaeta** (Villeneuve).

Muscina longicornis, Stein, 1909, p. 221 (non Macquart, 1851); 1919, a, p. 111, and b, p. 68.

Larva (without a name), Rodhain, 1914, p. 214, fig. 1.

Muscina heterochaeta, Villeneuve, 1915, p. 225, fig. 1.

Passeromyia heterochaeta, Rodhain and Villeneuve, 1915, p. 593; Rodhain and Bequaert, 1916, p. 250, figs. 1–6, pl. xix, fig. 2; Roubaud and Van Saceghem, 1916, p. 765; Roubaud, 1918, p. 428; Stein, 1919, p. 86; Patton, 1920, p. 30, pl.; Engel, 1920, p. 258.

Geographical distribution. Africa: Nyasaland, Port Herald; N.W. Rhodesia, Chilanga; Katanga, Elisabethville; British East Africa, Mombasa; Belgian Congo, Ouelle, Leopoldsville, Boma, etc. I have in my collection specimens from Usambara, Nguelo.

Asia: India, Madras; Java, Batavia; China, Kamsi. I have received numerous specimens from S. China, Canton, by Prof. C. W. Howard.

Ethology. The species has been found in the nests of various species of birds of the genera *Passer*, *Hirundo*, *Cinnyris*, *Spermestes*, *Sitagra*, *Ploceus*, etc.

According to Rodhain and Bequaert the larvae of *Passeromyia* have the same habits of intermittent haematophagy as observed in the floor maggot and other African Calliphorines belonging to the genera *Auchmeromyia* and *Chaeromyia* which live upon the blood of bare-skinned mammals.

It is interesting to note that *Passeromyia*, as a bird-parasite, is widely spread over the whole tropical region of the Old World only. There are however true Calliphorine flies the larvae of which live upon birds and have the same habits of intermittent haematophagy as is the case in *Passeromyia*. These flies belong to the well-known genus *Protocalliphora* which we shall examine presently.

II. *PROTOCALLIPHORA.*

There is a marked tendency both in Europe and in N. America to place the three species of haematophagous Calliphorine flies (*caerulea* R. D., *azurea* Fall., and *metallica* Tyler Townsend) in the genus *Phormia*.

The genus *Phormia* was established by Robineau-Desvoidy in 1849 and accepted by Coquillet in 1910 (p. 589) for the species *Musca regina* Meigen 1826 which differs markedly from the above mentioned calliphorine species.

The calliphorine bird parasites cannot therefore be placed with the species *regina* Meigen in the same genus *Phormia*. As to the new generic name *Euphormia* proposed by Tyler Townsend in 1919 (p. 542) for the genotype *regina* it becomes quite superfluous, and was introduced only through misinterpretation of Villeneuve's statements (see 1911, p. 84).

The right generic name for the bird parasites is that of *Protocalliphora* Hough 1899, as it has already been used by me in the third volume of the *Katalog der palaearktischen Dipteren*, pp. 544–545. The true genus *Phormia* thus remains a monotype, with the species *regina*, while in the genus *Protophormia* Tyler Townsend 1908 must be placed the species *terraenovae* Robineau-Desvoidy 1830 (= *groenlandica* Zetterstedt 1838)[1] and *Boganidae* Erichson 1851.

There has been some discussion about the validity of the described species of *Protocalliphora*. Hendel in 1901 (p. 29) distinguished in this genus five different species, while Hough, Villeneuve and Bequaert accepted only two species which were subsequently united by Roubaud (1918) into a single species. However, Kramer (1911, p. 43) has already shown that the species can be distinguished by the structure of the male genitalia; and recently Engler (1920) clearly established the existence of the two distinct European species by the study of the structure of the larval, pupal and adult stages. In addition to the two European species Tyler Townsend (1919) has added a third North American species: *metallica*. Of the two European species *caerulea* is the commoner. It shows however in addition to sexual dichroism, some variation in the breadth of the frons in the male and in the colour of the calypters. Being often the unique species of *Protocalliphora* present in collections, it was erroneously subdivided into two or more species under the names of *sordida*, *azurea*, *braueri*, etc.; the other species *azurea* is more uniform but very often wanting in collections.

The three known species of *Protocalliphora* may be distinguished as follows:

1 (4). Parafacialia without golden spot above.

2 (3). Parafacialia (viewed obliquely from above) smooth and uniformly covered with whitish pollen or dust. The two sexes differ in colour: the male has the thorax and abdomen of metallic dark blue coloration with scarce

[1] In the *Catalogue of Palaearctic Diptera* I have erroneously reported this species under the name *caerulea* R.-D., which belongs to *Protocalliphora*.

pollen; the female showing golden-greenish thorax and metallic green abdomen with bluish reflects and a thin whitish pollen covering all the segments except the last one. Frons of the male more or less narrow, not broader than the ocellar triangle; male genitalia in lateral view show acute paralobes and straight mesolobe. Females with the middle frontal stripe three times broader than one of the parafrontalia; average size 9–11 mm. . *caerulea* R.-D.

2 (1). Parafacialia with whitish pollen distributed in irregular rows with black interspaces. In both sexes the thorax is of a dark blue metallic colour with scarce pollen and the abdomen of a glittering bluish-green colour devoid of pollen and with a distinct dark longitudinal median stripe upon the second and third segments. Frons in the male distinctly broader, being about twice as broad as the ocellar triangle; the male genitalia with the paralobes broadly obtuse and with curved mesolobe. Parafrontalia of the female broader, the middle frontal stripe being twice as broad as one of them; average size 11–14 mm. . . . . *azurea* Fall.

4 (1). Parafacialia each with a conspicuous golden spot at the upper end. Thorax metallic, greenish-black to bright green colour with grey pollen and three nearly equal longitudinal stripes of the ground colour. Abdomen metallic dark bluish-green to bright cupreous or golden-green colour with scarce silvery pollen; anal segment varies always from cupreous to golden-green colour. Calypters white to buff yellow. Size 7–8·5 mm. Only female known . . . . . *metallica* T. T.

The synonymy of the three above described species of *Protocalliphora* is as follows:

Protocalliphora.

Hough, 1899, a, p. 66 and b, p. 289.

Avihospita, Hendel, 1901, p. 29 and 68; b, p. 210[1]; Aldrich, 1901, p. 68.

1. **Protocalliphora caerulea** (Robineau-Desvoidy).

Phormia caerulea, Robineau-Desvoidy, 1830, p. 466; 1863, p. 846.

Lucilia caerulea, Macquart, 1835, p. 256; Meigen, 1838, p. 295; Schiner, 1862, p. 591; de Meijere, 1902, p. 682, fig. 54.

Protocalliphora caerulea, Falcoz, 1921, p. 139.

Musca azurea, Meigen (nec Fallén!), p. 63; ? Rossi, 1848, p. 59, note.

Calliphora azurea, Schiner, 1862, p. 585; Nowicki, 1867, p. 44; Brauer, 1883, p. 74; Verrall, 1886, p. 231; Strobl, 1893, p. 104; Brauer and Bergenstamm, 1894, pp. 546 and 568; Pandellé, 1896, p. 214; Grimshaw, 1901, p. 27.

Protocalliphora azurea, Hough, 1899, p. 289, fig. 11; Aldrich, 1905, p. 524; Bezzi, 1907, p. 544, p.p.; Villeneuve, 1910, p. 313; Nielsen, 1911, p. 205.

Avihospita azurea, Hendel, 1901, p. 29.

[1] The *Catalogue of Palaearctic Diptera*, p. 444, contains also the genus *Philornis* Meinert as a synonym of *Protocalliphora*. The late Dr Nielsen, 1911, p. 207, pointed out this error, which is not mine (only pp. 1–597 of vol. III being my work) but that of Brauer, 1894, p. 568.

Phormia azurea, Villeneuve, 1911, p. 84 and 1913, p. 132; Surcouf and Gonzalez-Rincones, 1912, p. 135; Rodhain and Bequaert, 1916, p. 245; Rodhain and Villeneuve, 1915, p. 593; Roubaud, 1918, p. 420, pl. v; Plath, 1919, a, p. 30, b, p. 191, c, p. 373; Patton, 1920, p. 30.

Musca sordida, Zetterstedt, 1838, col. 657, 1845, p. 1332, and 1859, p. 6185; Bonsdorff, 1866, p. 150.

Pollenia sordida, Rondani, 1862, p. 198; E. Corti, 1897, p. 140.

Avihospita sordida, Hendel, 1901, p. 29.

Protocalliphora sordida, Villeneuve, 1910, p. 313; Kramer, 1911, p. 43, pl. iii.

Phormia sordida, Villeneuve, 1911, p. 84 and 1913, p. 132; Roubaud, 1914, p. 27, and 1915, a, p. 77, b, p. 94, fig.; Rodhain and Villeneuve, 1915, p. 593; Rodhain and Bequaert, 1916, p. 244; Roubaud, 1917, p. 434; Villeneuve, 1918, p. 158; Engel, 1920, p. 256, fig. 8.

Lucilia dispar, Léon Dufour, 1845, p. 205, pl. ii; Zetterstedt, 1849, p. 3269, *obs.*

Phormia dispar, Robineau-Desvoidy, 1849, p. iv.

Calliphora nidicola, v. Heyden in Nowicki, 1867, p. 44, note.

Phormia nigripalpis, Robineau-Desvoidy, 1863, p. 846.

Phormia corusca, Robineau-Desvoidy, 1863, p. 849.

Avihospita braueri, Hendel, 1901, p. 29.

Geographical distribution. The species has been found throughout Europe, from Lapland to Sicily. Its distribution in North America is not yet thoroughly known, but from Plath's observations it seems that the species is prevalent in the west of the United States. The species was also recorded from Hawaii; if this is not an importation by man, the fly must have a very wide distribution.

Ethology. The habits of the larvae were first described by Léon Dufour and more recently Dr Roubaud has established their habit of intermittent haematophagy and that they cannot live as subcutaneous parasites[1].

The species has been observed in nests of *Corvus*, *Passer*, *Hirundo*, *Cotyle*, *Parus*, *Ruticilla*, etc. in Europe, and of *Pipilo*, *Hylocichla*, *Merula*, *Ampelis*, *Dendroicha*, *Petrochelidon*, *Passer*, *Carpodacus*, *Zonotrichia*, *Melospiza*, *Astragalinus*, etc., in North America. All these birds belong to the *Passeres*.

2. **Protocalliphora azurea** (Fallén).

Musca azurea, Fallén, 1816, p. 245 and 1821, p. 46; Zetterstedt, 1838, col. 657 and 1845, p. 1334; Bonsdorff, 1866, p. 150.

Pollenia azurea, Rondani, 1862, p. 197.

Protocalliphora azurea, Bezzi, 1907, p. 544, p.p.; Villeneuve, 1910, p. 313, p.p.; Kramer, 1911, p. 43, fig.

Phormia azurea, Engel, 1920, p. 257, fig. 9.

[1] According to Roubaud the puparia of this fly are sometimes parasitised by a Hymenopteron *Nasonia brevicornis* Ashm.

Musca chrysorrhoea, ? Meigen, 1826, p. 60.

Calliphora chrysorrhoea, Macquart, 1835, p. 263; Schiner, 1862, p. 585; Brauer, 1883, p. 74; Strobl, 1894, p. 70; Brauer and Bergenstamm, 1894, p. 546.

Protocalliphora chrysorrhoea, Hough, 1899, p. 289; Aldrich, 1905, p. 524.

Avihospita chrysorrhoea, Hendel, 1901, p. 29.

Avihospita n. sp., Hendel, 1901, p. 30.

Phormia chrysorrhoea, Tyler Townsend, in Plath, 1919, pp. 374 and 380.

? *Calliphora splendida*, Macquart, 1845, p. 324.

Phormia caerulea, Kramer, 1917, p. 27.

Geographical distribution. This fly has apparently the same distribution in Europe as the other species, but is much more rare and there are only a few precise records, those of all the earlier writers being in my opinion very doubtful. It has been assumed here that the descriptions in which the sexual dichroism is not clearly indicated, apply to the true *azurea*, because Fallén's original description refers to a species in which the males and the females are equally coloured. But even in this last case a confusion with *Protophormia terraenovae*, R.-D., is always possible. The species is also recorded from North America, its distribution there being not yet determined.

Ethology. The larval stages were described by Engel in 1920, and compared with those of *caerulea*. The habits of these larvae seem to be the same. Engel has obtained the species from subterraneous nests of *Riparia riparia*, and this is the unique precise record, which indicates a very peculiar habitat.

3. **Protocalliphora metallica** (Tyler Townsend).

Phormia metallica, Tyler Townsend, 1919, p. 379; Plath, 1919, p. 376.

? *Protocalliphora azurea*, Coutant, 1915, p. 145.

Geographical distribution. This species as far as it is known is exclusively a North American one; its range extends throughout the United States chiefly in the East, being very rare in the West. It is possible that the above mentioned *splendida*, Macquart, from Texas, may be synonymous with the present species.

Ethology. Plath found the larvae in nests of *Merula migratoria*. The larva from nests of *Corvus americanus* fully described by Coutant, may possibly belong to the present species; at any rate this larva cannot be that of *azurea* or of *caerulea* owing to the very important differences pointed out by Roubaud, 1918, pp. 423–424.

* * * *

The larvae of the above named species of *Passeromyia* and *Protocalliphora* live in bird nests, and attracted by positive thermotropism to the naked bodies of the young nestlings, they can suck their blood. But this type of intermittent haematophagy makes it impossible for them, as shown by Dr Roubaud, to become permanent parasites. There are however several records of fly-larvae found in subcutaneous tumours on young birds and attributed

erroneously to *Protocalliphora*. These records are enumerated here separately, as they do not belong to the above named flies.

In Europe they are as follows:

Schneider, 1866, p. 89, and Kirsch, 1867, p. 245, pl. iii, figs. 3–4, on *Passer domesticus*, attributed to *Prot. caerulea*.

Portschinsky, 1887, p. 17, pl. i, figs. 9–10, on *Anthus pratensis*, attributed to *Prot. azurea* (*Pollenia*).

Meinert, 1889, p. 315, on *Emberiza miliaria*, attributed to *Prot. caerulea*.

Brauer and Bergenstamm, 1894, p. 546, on *Passer domesticus*, attributed to *Prot. caerulea*, and on *Riparia riparia*, attributed to *Prot. azurea*.

Pavay-Vajna, 1909, p. 288, on *Motacilla alba*, attributed to *Melinda cognata* (*Onesia*).

Heinroth, 1916, p. 158, on *Motacilla*, attributed to *Prot. caerulea*.

And in North America:

Henshaw, 1908, p. 87, on *Sialis sialis*, attributed to *Prot. azurea*.

Miller, 1909, p. 1, the same.

Plath, 1919, p. 377, on *Astragalinus tristis*.

It is probable that there are here more than one kind of parasite, belonging to the Calliphorine or other flies.

The genera *Onesia* and *Melinda* must be excluded from this list, as Dr Keilin's researches show that the former is parasitic in earthworms and the latter lives in snails (1915 and 1919). The gen. *Lucilia* seems to be questionable, as Hesse's observations of 1921, p. 154, are not convincing.

If we have to deal with some Calliphorine larva, the gen. *Nitellia* must be taken into consideration. This genus was established in 1830 by Robineau-Desvoidy, but was united with *Pollenia* by all subsequent writers except Hendel and Tyler Townsend. It differs from *Pollenia* in having the common basal stem of the Radius ciliated above, as in *Protocalliphora*, with which it shows moreover a notable resemblance in the shape of thorax, in the flattened body and in the whole facies. The type species (*vespillo* Fabricius, 1786) is common in Europe and is present even in North America; its bionomics are still unknown.

III. *PHILORNIS*.

Muscid larvae, typically living as subcutaneous parasites on birds, have been found only in the Neotropical Region. They belong to the Anthomyidae and not to the Calliphorinae.

It seems that in Central and South America there are several species which at present are not well distinguished. The first case was recorded by Macquart in 1853 from San Domingo under the name of *Aricia pici* parasitic on *Picus striatus*[1]. The species was subsequently reported under the same name by Blanchard in 1896 who on Brauer's authority established its synonymy with *Mesembrina anomala* Jaennicke. The birds infested were *Oriolus cayennensis*

[1] Macquart's assertion that Sallé had seen similar tumours in Mexico on other birds (*Icterus*) and even on squirrels is doubtful; the latter case may have been due to some Cuterebrine larva

and *Or. mexicanus* from French Guiana. Blanchard had already recorded it in 1895 under the name of *Spilogaster anomalus* as a subcutaneous parasite of man.

In 1901 A. de Miranda Ribeiro accepted the above synonymy on the authority of Prof. Mik of Vienna, to whom he had sent specimens for identification. These specimens were caught on the bird *Peristera rufaxilla*.

Meinert in 1889 had already described, from an unidentified Brazilian bird nestling, a muscid larva as *Philornis molesta* which evidently belongs to the same group. Other allied forms were described in 1895 by Tyler Townsend from the West Indies under the name of *Mydaea spermophilae*, found on birds of the genera *Spermophila* and *Mimus*.

In two papers of 1911 and 1913 the late Dr J. C. Nielsen has studied very thoroughly two species of bird parasites under the names of *Mydaea anomala* and *Mydaea torquans*; the material examined was obtained from Argentina, and the larvae were found as subcutaneous parasites in tumours on various birds, both old and young ones; *torquans* occurring on birds of the genera *Spermophila*, *Mimus*, *Homorus* and *Pitangus*, and *anomala* on *Xiphocolaptes albicollis*.

The Rev. J. Aiken (1913) has described *Mydaea pici* from British Guiana and has recognised four different species belonging to the present group. On the contrary Lutz and Neiva in 1912, mentioning that subcutaneous larvae are frequent on young birds in Brazil, think that they all belong to a single species, *Mydaea pici* Macquart. Engel in 1920 expressed a similar opinion.

In 1916 Neiva and Penna recorded *Mydaea pici* from numerous birds in Central Brazil, saying that the larvae are so frequent as to be commonly named "*berro*"; they were found on birds of the genera *Cassicus*, *Furnarius*, *Molothrus*, *Paroaria*, *Amazona*, *Pionus*, etc., mostly belonging to the *Passeres*.

The late Prof. Stein in 1918 revised Mik's types of 1901 under the name of *Mydaea anomala*; and in the World Catalogue of 1919 stated that *anomala* and *torquans* form a single species.

In my opinion there are in the Neotropical Region several species of Anthomyidae, the larvae of which live in subcutaneous tumours of birds. This opinion is supported by the fact that in a collection of Brazilian flies belonging to this group sent to me some years ago by Dr Lutz, Prof. Stein has recognised the following species of *Mydaea*: *brevipectinata* Stein, *latipalpis* Stein, *sparsiplumata* Stein and *tinctinervis* Stein, all described in 1918. It is probable that some of these species were bred from subcutaneous larvae.

As a conclusion, we can provisionally place the South American Anthomyidae with the larvae forming the subcutaneous tumours in birds together under the generic name of *Philornis*.

Philornis.

Meinert, 1889, p. 315.

1. **Philornis pici** (Macquart).

Aricia pici, Macquart, 1853, p. 657, pl. xx, 2.

Hylemyia pici, Osten Sacken, 1878, p. 167; Aldrich, 1905, p. 553.

Mydaea pici, Miranda Ribeiro, 1901, p. 156, pl. i; Busck, 1906, p. 2; Lutz and Neiva, 1912, p. 133; Aiken, 1913, p. 3 (sep.), figs. 1–11; Rodhain and Bequaert, 1916, p. 247; Neiva and Penna, 1916, p. 111; Keilin, 1917, pp. 399 and 436; Stein, 1919, p. 123; Engel, 1920, p. 250.

? *Hylemyia angustifrons*, Loew, 1861, p. 41.

Mesembrina anomala, Jaennicke, 1867, p. 377, pl. ii, fig. 4.

Spilogaster anomala, Brauer and Bergenstamm, 1893, p. 209, note 114, 1; Blanchard, 1895, p. 118 and 1895, p. 652, pl. 17, figs. 5–9.

Mydaea anomala, Nielsen, 1913, p. 252, figs. 1–4; Aiken, 1913, p. 3 (sep.); Keilin, 1914, p. 114 and 1917, p. 399; Stein, 1918, p. 212.

Philornis molesta, Meinert, 1889, p. 315, pl. vi.

Geographical distribution. If all the above records belong really to one species, it must have a wide range of distribution over Neotropical Region, from Cuba, San Domingo and Central America to Argentina.

Ethology. Well illustrated by Meinert and others. The larva pupates in a cocoon of earth cemented by a white substance. This fact seems to be uncommon in Anthomyidae, but is observed also in the tropical *Synthesiomyia nudiseta*, v. d. Wulp, besides the cases recorded by Dr Keilin, 1917, p. 437.

2. **Philornis torquans** (Nielsen).

Mydaea torquans, Nielsen, 1913, p. 252, fig. 3; Aiken, 1913, p. 3 (sep.); Keilin, 1914, p. 114 and 1917, p. 399.

Mydaea anomala, Nielsen, 1911, p. 195, figs. 1–14.

Geographical distribution. At present only known from Argentina.

Ethology. The larva pupates freely, without producing a cocoon.

3. **Philornis spermophilae** (Tyler Townsend).

Mydaea spermophilae, Tyler Townsend, 1893, p. 381; 1894, p. 173 and 1895, p. 79; Aldrich, 1905, p. 543; Aiken, 1913, p. 3 (sep.).

Mydaea spermophila, Keilin, 1917, p. 399.

Geographical distribution. Only known from Jamaica; but Townsend, *l.c.*, records a different species, which infests birds in Trinidad.

Ethology. The larva does not make a cocoon for pupation.

These three flies can be distinguished as follows:

1 (4). Third antennal joint about twice as long as the second[1]; abdomen

[1] The figure given by Blanchard, 1896, pl. 17, figs. 5–8, if really belonging to *pici* (*anomala*), must be somewhat inaccurate, showing, in opposition with the figures of Macquart, Jaennicke, Miranda Ribeiro and Aiken, a much longer third antennal joint and a bare arista.

more or less yellowish at the base; legs as a rule entirely yellowish, at least in the male.

2 (3). Frons more narrow, the parafrontalia of the male almost touching above, and the middle stripe of the female being not broader than one of the parafrontalia; sides of the face yellowish; legs entirely yellow even in the male . . . . . *pici* Macquart.

3 (2). Frons broader, the parafrontalia of the male well separated to the vertex and the middle stripe of the female broader than one of the parafrontalia; sides of the face silvery; legs of the female with blackish femora. *torquans* Nielsen.

4 (1). Third antennal joint about three times as long as the second; abdomen entirely black and the silvery pollen forms a somewhat marmorate pattern; legs brownish, with basal portion of femora darker. *spermophilae* T. T.

IV. *CARNUS.*

The unique non-pupiparous Dipteron, which in the adult stage is parasitic on birds, is the strange *Carnus hemapterus*; the fly is haematophagous and is to be found chiefly on young birds, while the larva lives in the nests, but is saprophagous.

The fly was described and figured by Nitzsch about a century ago, was redescribed and figured by Egger in 1854 under the same name, and owing to a misinterpretation of the original description was in 1862 renamed by Schiner as *Cenchridobia eggeri*. Thus for a long time it has been believed that there were two species, one belonging to the Pupipara, and one to the Acalypterata of the family Borboridae (Schiner), or Sepsidae (Brauer).

Collin in 1911, in a short but important paper, has cleared up the matter recognising but a single species and locating it in the family Milichiidae.

In the subsequent year there appeared the paper of Prof. de Meijere, with the confirmation of the singular fact that the fly emerges from the puparium fully winged, and loses subsequently the wings, short stumps of which remain only as in the Pupiparous gen. *Lipoptena*. Thus in my paper of 1916 on the reduction of wings in the Diptera, I have included *Carnus*, with *Lipoptena*, *Echestypus* and *Ascodipteron*, in no. 7 of my graduation, p. 108.

A supposed second species of the gen. *Carnus* was described in 1913 by Stobbe, but its distinction seems to be very doubtful. Engel in his recent paper has added some new records, and therefore this interesting fly is at present known to occur on birds of the genera *Aquila*, *Falco*, *Picus*, *Iynx*, *Sylvia*, *Sturnus* and *Coloeus*. I have received from Prof. B. Grassi a couple of specimens caught at Maccarese, near Rom, by Luigioni on a nestling of *Falco*; these specimens are dark coloured and bristly as in *setosus*.

Carnus.

Nitzsch, 1818, p. 305 and p. 283.

Cenchridobia, Schiner, 1862, p. 435, and 1864, p. 334.

1. **Carnus hemapterus,** Nitzsch.

Carnus hemapterus, Nitzsch, 1818, p. 305; Germar, 1822 (?), pl. 24 and 25; Egger, 1854, p. 3, pl. ii, figs. 7–11; Bezzi, 1900, p. 522; Collin, 1911, p. 138; Bezzi, 1911, p. 115; de Meijere, 1912, pp. 1–18, figs. 1–12; Melander, 1913, p. 237; Stobbe, 1913, p. 193; Bezzi, 1916, pp. 108 and 177; Wasielewski and Wuelker, 1918, p. 117; Engel, 1920, pp. 249 and 258; Frey, 1921, p. 151, pl. x, fig. 125.

Cenchridobia eggeri, Schiner, 1862, p. 436 and 1864, p. 335; Brauer, 1880, p. 117, 3 and 1883, pp. 40 and 87; Bezzi, 1900, p. 521; Becker, 1905, p. 36.

Carnus setosus, Stobbe, 1913, p. 193.

Geographical distribution. Only known from Europe: Finland, Germany, Austria, Hungary, Roumania and Middle Italy.

V. *CHORTOPHILA* AND *NEOTTIOPHILUM.*

It may be finally recorded that in bird nests are to be found many other species of Myiodaria, which are not parasitic, but only inquiline, living probably on excrement or on organic refuse. Falcoz in 1914, p. 60, has pointed out the great number of dipterous larvae found in bird nests. It is to be noted that these flies, as far as is known, belong to the lower forms of *Anthomyidae* and even to the *Acalypterata.*

Of the former there are only the two following species, one from Europe and one from North America:

1. **Chortophila cannabina,** Stein, 1916, p. 169; Kramer, 1917, p. 49; Engel, 1920, p. 258.

Germany; bred by Kramer from larvae in nest of *Acanthis cannabina.*

2. **Chortophila nidicola** (Aldrich).

Hylemyia nidicola, Aldrich in Plath, 1919, p. 380.

State of Washington, U.S.A.; bred by Plath from larvae found in various bird nests.

Among Acalypterate flies there is the following very interesting genus:

Neottiophilum.

Frauenfeld, 1868, p. 894.

1. **Neottiophilum praeustum** (Meigen).

Dryomyra praeusta, Meigen, 1826, p. 257.

Neottiophilum praeustum, Mik, 1882, pp. 98 and 194, 1887, p. 34 and 1894, p. 166; Brauer, 1883, pp. 40 and 86; v. Roeder, 1892, p. 204 and 1895, p. 270; Strobl, 1894, p. 86; Becker, 1902, p. 219 and 1905, p. 38; Bezzi, 1911, p. 115; Kramer, 1917, p. 58; Engel, 1920, p. 250.

Neottiophilum fringillarum, Frauenfeld, 1868, p. 895.

Blephariptera cartereaui, Bigot, 1881, p. 370.

Geographical distribution. At present known only from Central Europe: France, Germany and Austria. The adult fly seems to be rare, and was found mostly in houses, on windows; it lives probably on trees.

Ethology. The fly was bred from puparia found in nests of *Fringilla coelebs* and of *Passer domesticus*, but almost nothing is known about the larva.

VI. CONCLUSIONS.

1. The Myiodaria living with birds show a parallelism between the grades of their parasitic adaptation and their systematic position.

2. The lower forms—*Acalypterata* have saprophagous larvae, living in the nests of several orders of birds: Scansores, Passeres and Raptores. In the larval stage they feed upon decaying organic matter, while in the adult stage they are, in some cases, blood-sucking (*Carnus*).

3. The intermediate forms—*Anthomyidae* show two grades of adaptation: (*a*) lower forms, the larvae of which are mainly saprophagous or phytophagous (*Chortophila*) and which, like the *Acalypterata*, live in the nests upon decaying substances; (*b*) higher forms the larvae of which are mainly carnivorous and have adapted themselves to two modes of life: (*A*) as subcutaneous parasites (*Philornis*) of Scansores, Columbae, and Passeres; (*B*) as intermittent haematophaga, on Passeres (*Passeromyia*).

4. The higher Myiodaria—the *Calliphorinae* show in their larval stage the two last types of parasitic adaptation, *i.e.* (*a*) intermittent haematophagy (*Protocalliphora*), and (*b*) possibly a subcutaneous mode of life on Passeres only.

5. The adult flies of all the intermediate and higher Myiodaria are non-bloodsucking. It seems to be a rule among the Diptera that the forms with haematophagous adults have non-haematophagous larvae and *vice versa*.

6. All these facts have to be taken into consideration in the study of other parasitic Myiodaria and especially the heterogeneous groups like Pupipara and Oestridae which, undoubtedly, are of polyphyletic origin, and are derived from lower, intermediate and higher Myiodaria.

VII. BIBLIOGRAPHY.

AIKEN, J. (1913). A subcutaneous larva of Mydaea. *B. G. Medical Annual*, pp. 1–4, 3 pls.

ALDRICH, J. M. (1901). Synonymische Notiz. *Wien. Ent. Zeit.* XX, p. 68.

—— (1905). *A Catalogue of North American Diptera (or Two-winged Flies)*, pp. 680. Washington.

BECKER, TH. (1902). Die Meigen'schen Typen der sogen. *Muscidae acalypterae* (*Muscaria holometopa*) in Paris und Wien. *Zeitschr. für Hym. und Dipt.* II, pp. 209–256, 289–320, 337–349.

—— (1905). *Katalog der paläarktischen Dipteren*, IV, pp. 328. Budapest.

BEZZI, M. (1900). Sulla presenza del genere *Chionea* Dalman in Italia, e la riduzione delle ali nei ditteri. *Rendic. Istit. Lomb.* Milano, XXXIII, pp. 511–526.

BEZZI, M. (1907). *Katalog der paläarktischen Dipteren.* III, pp. 1–597. Budapest.

—— (1911). Études systématiques sur les Muscides hématophages du genre Lyperosia. *Arch. de Parasit.* Paris, XV, pp. 110–143, 15 figs.

—— (1916). Riduzione e scomparsa delle ali negli insetti ditteri. *Natura,* Milano, VII, pp. 85–182, 11 pls.

BIGOT, J. M. F. (1877). Diptères nouveaux ou peu connus. XI. Notes et mélanges diptérologiques. *Ann. Soc. Ent. Fr.* (5) VII, pp. 260–262.

—— (1881). Diptères nouveaux ou peu connus. XXVI. *Ibid.* (6) I, pp. 363–371.

—— (1887). Diptères nouveaux ou peu connus. Muscidi (J. B.). *Bull. Soc. Zool. Fr.* XII, pp. 581–617.

BLANCHARD, R. (1895). Note in *Bull. Soc. Zool. Fr.* XX, p. 118, séance du 14 Mai.

—— (1896). Contributions à l'étude des Diptères parasites. (Troisième série.) XI. Sur l'*Aricia pici* Macq. *Bull. Soc. Ent. Fr.* LXV, pp. 652–654, pl. XVII, figs. 5–9.

BONSDORFF, J. E. (1866). *Finlands Twåvingade Insekter* (*Diptera*), etc. Andra delen, pp. 306. Helsingfors.

BRAUER, F. (1880). Die Zweiflügler des Kaiserlichen Museums zu Wien. I. *Denkschr. d. math.-naturwiss. Cl. der K. Akad. d. Wiss.* Wien, XLII, pp. 105–216, pl. 6.

—— (1883). Die Zweiflügler des Kaiserlichen Museums zu Wien. III. *Ibid.* XLVII, pp. 1–100, pl. 5.

BRAUER, F. and BERGENSTAMM, J. v. (1893). Die Zweiflügler des Kaiserlichen Museums zu Wien. VI. Vorarbeiten zu einer Monographie der *Muscaria schizometopa* (exclusive Anthomyidae). Pars III. *Ibid.* LX, pp. 89–240.

—— (1894). Die Zweiflügler des Kaiserlichen Museums zu Wien. VII. Vorarbeiten zu einer Monographie der *Muscaria schizometopa* (exclusive Anthomyidae). Pars IV. *Ibid.* LXI, pp. 537–624.

BUSCK, A. (1906). *Mydaea pici* Macq. *Proc. Ent. Soc. Washington,* VIII, pp. 2–3.

COLLIN, J. E. (1911). On *Carnus hemapterus* Nitzsch (*Cenchridobia eggeri* Schiner) and its systematic position among the Diptera. *Novit. zoolog.* XVIII, pp. 138–139.

COQUILLETT, D. W. (1910). The type-species of the North American genera of Diptera. *Proc. U.S. Nat. Museum,* XXXVII, pp. 499–647.

CORTI, E. (1897). Aggiunte alla Fauna ditterologica della provincia di Pavia. Terza Centuria. *Bull. Soc. entom. ital.* XXIX, pp. 136–143.

COUTANT, A. F. (1915). The habits, life-history and structure of a blood-sucking Muscid larva (*Protocalliphora azurea*). *Journ. of Parasit., Urbana, Ill.* I, pp. 134–150.

DUFOUR, L. (1845). Histoire des métamorphoses de la *Lucilia dispar* (Diptère). *Ann. Soc. Ent. Fr.* (2) III, pp. 205–214, fig.

EGGER, J. (1854). Beiträge zur bessern Kenntniss des *Carnus hemapterus* Nitzsch. *Verhandl. zool.-bot. Ver. Wien,* IV, pp. 3–7, pl. I, figs. 7–11.

ENGEL, E. O. (1920). Dipteren, die nicht Pupiparen sind, als Vogelparasiten. *Zeitschr. f. wiss. Insektenbiol.* XV, pp. 249–258, 9 figs.

FALCOZ, L. (1914). *Contribution à l'étude de la Faune des Microcavernes. Faune des terriers et des nids,* pp. 185, 1 pl., 38 figs. Lyon.

—— (1921). Matériaux pour l'étude de la faune pholéophile Première. Note: Diptères. *Bull. Soc. Ent. Fr.* pp. 137–142.

FALLÉN, C. F. (1816). Beskrifning öfver de i Sverige funne flugarter, som kunna föras till slägtet Musca. *Vetensk. Acad. Handl.* pp. 226–254.

—— (1821). *Diptera Sueciae.* Vol. II, *Monographia Muscidum,* Pars IV, pp. 41–48 (resp. Sundewall). Lundae, 1818–1825.

FRAUENFELD, G. (1868). Zoologische Miscellen. XV. *Verh. der zool.-bot. Ges. Wien,* XVIII, pp. 885–902.

FREY, R. (1921). Studien über den Bau des Mundes der niederen Diptera Schizophora, etc. *Acta Soc. Faun. et Flora Fenn.,* 48. pp. 3–245, pl. X.

GERMAR, E. F. (1822–?). *Fauna Insectorum Europae.* Fasc. IX, tab. 24–25. Halae, 1817–1840.

GILBERT, P. A. (1919). A Dipterous Parasite of Nestling Birds. *Emu*, XIX, pp. 48–49.

GRIMSHAW, P. H. (1901). *Fauna Hawaiiensis or the Zoology of the Sandwich* (Hawaiian) *Isles*, etc. Vol. III, Part I, *Diptera*, pp. 1–77, 3 pls. Cambridge.

HEINROTH, — (1916). *Journ. f. Ornithologie*, I, pp. 158–159.

HENDEL, FR. (1901 *a*). Beitrag zur Kenntniss der Calliphorinen (Dipt.). *Wien. Ent. Zeit.* XX, pp. 28–33.

—— (1901 *b*). Ueber einige neue oder weniger bekannte europäische *Muscaria schizometopa*. *Verh. zool.-bot. Ges. Wien*, LI, pp. 198–211.

HENSHAW, W. H. (1908). A parasitic fly injurious to our native birds. *The Auk*, Cambridge, Mass. (N.S.), XXV, pp. 87–88.

HESSE, E. (1921). Bemerkung zu: E. Engel, Dipteren, die nicht Pupiparen sind, als Vogelparasiten. *Zeitschr. f. wiss. Insektenbiol.* XVI, p. 154.

HOUGH, G. DE N. (1899 *a*). Some North American genera of the Dipterous group *Calliphorinae* Girschn. *Entom. News*, X, pp. 62–66.

—— (1899 *b*). Synopsis of the *Calliphorinae* of the United States. *Zoolog. Bull.* II, pp. 283–294, 11 figs.

JAENNICKE, F. (1867). Neue Exotische Dipteren aus den Museen zu Frankfurt a. M. und Darmstadt. *Abhandl. der Senckenb. Ges.* VI, pp. 311–407, pl. 2.

KEILIN, D. (1915). Recherches sur les larves de Diptères Cyclorhaphes. *Bull. Sci. de la Fr. et de la Belg.* (7) XLIX, pp. 15–198, pls. I–XVI, fig. 27.

—— (1917). Recherches sur les Anthomyides à larves carnivores. *Parasitology*, IX, pp. 325–450, pls. V–XV.

—— (1919). On the life-history and larval anatomy of *Melinda cognata* Meigen (*Diptera Calliphorinae*) parasitic in the snail *Helicella* (*Heliomanes*) *virgata* Da Costa, with an account of the other Diptera living upon Molluscs. *Ibid.* XI, pp. 430–455, pls. XXII–XXV, 6 figs.

KIRSCH, TH. (1867). Ueber zwei Fliegenlarven aus dem Nacken eines jungen Sperlings. *Berl. ent. Zeitschr.* XI, pp. 245–246, pl. III, figs. 3–4.

KRAMER, H. (1911). Die Tachiniden der Oberlausitz. *Abh. naturf. Ges. in Görlitz*, XXVII, pp. 1–50, pls. 1–3.

—— (1917). Die Musciden der Oberlausitz. *Ibid.* XXXIII, pp. 1–96, figs.

LOEW, H. (1861). Diptera aliquot in Insula Cuba collecta. *Wien. Entom. Monatsschr.* V, pp. 33–43.

LUTZ, A. and NEIVA, A. (1912). Notas dipterolojicas. A proposito da *Mydaea pici* Macquart. *Mem. do Inst. Osw. Cruz*, Rio de Janeiro, IV, pp. 130–135.

MACQUART, J. (1835). *Histoire naturelle des Insectes, Diptères*, II, pp. 703, pl. 12. Paris.

—— (1845). Diptères exotiques nouveaux ou peu connus. Supplément. *Mém. Soc. Sci. Lille* (1844), pp. 133–364, pl. 20. Also sep., Paris, 1846, pp. 238, 20 pls.

—— (1851). Diptères exotiques nouveaux ou peu connus. Suite du 4e Supplément publié dans les Mémoires de 1849. *Mém. Soc. Sci. Lille* (1850), pp. 134–294, pl. 14. Also sep., Paris, 1851, IV, with the first part, pp. 105 and 158, 28 pls.

—— (1853). Notice sur une nouvelle espèce d'Aricie, Diptère de la tribu des Anthomyzides. *Ann. Soc. Ent. Fr.* (3) I, pp. 655–660, pl. XX, n. ii.

MEIGEN, J. W. (1826). *Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten*, Fünfter Theil, pp. 412, pl. 13. Hamm.

MEIJERE, J. C. H. DE (1902). Ueber die Prothoracalstigmen der Dipterenpuppen. *Zoolog. Jahrbüch.* XV, pp. 623–692, pls. 32–35.

—— (1912). Zur Kenntnis von *Carnus hemapterus* Nitzsch. *Schrift. d. Phys.-Ökon. Ges. zu Königsberg*, LIII, pp. 1–18, figs. 1–12.

MEINERT, FR. (1889). *Philornis molesta*, en paa Fugle snyltende Tachinarie. *Vidensk. Meddel. nat. Foren.* pp. 304–317, pl. VI.

MELANDER A. L. (1913). A Synopsis of the Dipterous Groups Agromyzinae, Milichiinae, Ochthiphilinae and Geomyzinae. *Journ. N. Y. Ent. Soc.* XXI, pp. 219–300, pl. VIII.

MIK, J. (1882). Ueber die Dipteren-Gattung *Neottiophilum* Frnfld. *Wien. Ent. Zeit.* I, pp. 194–197. The synonymy was already given in the same vol. p. 98, note 2.

—— (1887). Dipterologische Miscellen, IV, p. 21. Ein seltenes Dipteron. *Ibid.* VI, pp. 34–35.

—— (1894). Dipterologische Miscellen (2 Serie), V. *Ibid.* XIII, pp. 164–168.

MILLER, — (1909). *Worthington, Soc. Bird Life*, no. 2, pp. 1–8.

MIRANDA RIBEIRO, A. DE (1901). Sobre a *Mydaea pici* Macq. *Archiv. do Mus. nac. de Rio de Janeiro*, XI, pp. 153–156, pl. I.

NEIVA, A. and PENNA, B. (1916). Viajem cientifica pelo Norte da Bahia, sudoeste de Pernambuco, sul do Piauhi e de norte a sul de Goiaz. *Mem. do Instit. Osw. Cruz*, Rio de Janeiro, VIII, pp. 74–224, 28 pls.

NIELSEN, J. C. (1911). *Mydaea anomala* Jaenn., a parasite of South American birds. *Vidensk. Meddel. fra nat. Foren.* LXIII, pp. 195–208, figs. 1–14.

—— (1913). On some South American species of the genus *Mydaea*, parasitic on birds. *Ibid.* LXV, pp. 251–256, 4 figs.

NITZSCH, C. L. (1818). Die Familien und Gattungen der Thierinsecten (*insecta epizoica*) als ein Prodromus der Naturgeschichte derselben. *Germars Mag. d. Entomol.* III, pp. 261–316.

NOWICKI, M. (1867). Faunistische Miscellen. *Verh. der nat. Ver.* Brünn, p. 44.

OSTEN SACKEN, C. R. (1878). *Catalogue of the described Diptera of North America* (Second Edition), pp. 276. Washington.

PANDELLÉ, L. (1896). Études sur les Muscides de France. *Rev. d'Entom.* Caen, XV, pp. 214–215.

PATTON, W. S. (1920). Note on the occurrence of *Passeromyia heterochaeta* Villeneuve, in India. *Ind. Journ. Med. Res.* VIII, pp. 30–31, 1 pl.

PAVAY-VAJNA, FR. (1909). *Onesia cognata* als Vogelparasite. *Aquila*, XVI, pp. 288–290.

PLATH, O. E. (1919 *a*). Parasitism of nestling birds by fly larvae. *The Condor*, XXI, pp. 30–39.

—— (1919 *b*). A Muscid larva of the San Francisco Bay Region which sucks the blood of nestling birds. *Univ. Calif. Publ. Zool.* XIX, pp. 191–200.

—— (1919 *c*). The prevalence of *Phormia azurea* Fallén (larva parasitic on nestling birds) in the Puget Sound Region and data on two undescribed flies of similar habit. *Ann. Ent. Soc. Amer.* XII, pp. 373–381. With Appendices by Townsend and Aldrich.

PORTSCHINSKY, J. (1887). Diptera europaea et asiatica nova aut minus cognita (cum notis biologicis). *Hor. Soc. Ent. Ross.* XXI, pp. 3–20, pl. I.

ROBINEAU-DESVOIDY, J. B. (1830). Essai sur les Myodaires. *Mém. Savants étrang. Acad.* Paris, II, pp. 1–813.

—— (1849). Note sur la synonymie de la *Phormia regina* (Diptère). *Ann. Soc. Ent. Fr.* (2) VII, Bull. p. 4.

—— (1863). *Histoire Naturelle des Diptères des environs de Paris*, II, pp. 920. Paris.

RÖDER, V. v. (1892). Ein neuer Fundort der Dipteren *Neottiophilum praeustum* Mg. und *Acyglossa diversa* Rond. *Entom. Nachr.* XVIII, pp. 204–206.

—— (1895). Neue Fundorte der Diptere *Neottiophilum praeustum* Meig. *Wien. Entom. Zeit.* XIV, p. 270.

RODHAIN, J. (1914). Sur une larve de *Muscinae* vivant dans le nid de *Passer griseus* au Congo. *Rev. zool. Afric.* III, pp. 213–217.

RODHAIN, J. and VILLENEUVE, J. (1914). *Passeromyia*, genre nouveau des *Anthomyidae* (Dipt.), à larve hématophage parasite des jeunes oiseaux. *Bull. Soc. Path. exot.* VIII, pp. 591–593.

RODHAIN, J. and BEQUAERT, J. (1916). Histoire de *Passeromyia heterochaeta* Villen. et de *Stasisia* (*Cordylobia*) *Rodhaini* Ged. *Bull. Sci. de la Fr. et de la Belg.* (7) XLIX, pp. 236–289, 1 pl., 14 figs.

RODHAIN, J. (1919). Nouvelles observations sur la biologie de *Passeromyia heterochaeta* Villeneuve. *Bull. Biol. de la Fr. et de la Belg.* LII, pp. 499–510, 2 figs.

RONDANI, C. (1862). *Dipterologiae italicae Prodromus*, V, pp. 239. Parmae.

ROSSI, F. (1848). *Systematisches Verzeichniss der Zweiflügelichen Insecten (Diptera) des Erzherzogthumes Österreich mit Angabe des Standortes, der Flugzeit und einigen andern physiologischen Bemerkungen.* pp. 86. Wien.

ROUBAUD, E. (1914). *Études sur la Faune Parasitaire de l'Afrique occidentale Française.* Premier Fascicule, pp. 250, 4 pls., 70 figs. Paris.

—— (1915 *a*). Hématophagie larvaire et affinités parasitaires d'une mouche Calliphorine, *Phormia sordida*, parasite des jeunes oiseaux. *Bull. Soc. Path. exot.* VIII, pp. 77–79.

—— (1915 *b*). Les Muscides à larves piqueuses et suceuses de sang. *C.R. Soc. Biol.* Paris, LXXVIII, pp. 92–97, fig. 2.

—— (1917). Observations biologiques sur *Nasonia brevicornis* Ashm. chalcidide parasite des pupes des muscides. *Bull. Sci. de la Fr. et de la Belg.* (7) L, pp. 425–439, 1 fig.

—— (1918). Précisions sur *Phormia azurea* Fall. Muscide à larves hémophages parasites des Oiseaux d'Europe. *Bull. Biol. de la Fr. et de la Belg.* LI, pp. 420–430, pl. V.

ROUBAUD, E. and VAN SACEGHEM, R. (1916). Observations sur quelques Insectes et Acariens parasites du Bétail au Congo Belge. *Bull. Soc. Path. exot.* IX, pp. 763–767.

SCHINER, J. R. (1862). *Fauna austriaca. Die Fliegen (Diptera).* I Theil, pp. 674, 2 pls. Wien.

—— (1862). Vorläufiger Commentar zum dipterologischen Theile der "Fauna austriaca." V. *Wien. Entom. Monatsschr.* VI, pp. 428–436.

—— (1864). *Fauna austriaca. Die Fliegen (Diptera).* II Theil, pp. 658. Wien.

SCHNEIDER, O. (1866). Notiz in *Isis, Sitzungsber.* Dresden, p. 89.

STEIN, P. (1909). Neue Javanische Anthomyiden. *Tijdschr. voor Entom.* LII, pp. 205–271.

—— (1916). Die Anthomyiden Europas, etc. *Archiv f. Naturgesch.* LXXXI, pp. 1–224.

—— (1918). Zur weitern Kenntnis aussereuropaeischer Anthomyiden. *Ann. Mus. nat. Hung.* XVI, pp. 147–244.

—— (1919 *a*). Die Anthomyiden Gattungen der Welt, analytisch bearbeitet, nebst einem Kritisch-systematischen Verzeichnis aller aussereuropäischen Arten. *Archiv f. Naturg.* LXXXIII, pp. 85–178.

—— (1919 *b*). Anthomyiden aus Java, Sumatra, Waigeoe und Ceram. *Tijdschr. voor Entom.* LXII, pp. 47–86.

STOBBE, R. (1913). Zur Kenntnis der Gattung *Carnus* Nitzsch (= *Cenchridobia* Schiner) mit 1 nov. sp. (Dipt.). *Deutsch. Ent. Zeitschr.* pp. 192–194.

STROBL, G. (1893). Beiträge zur Dipterenfauna des österreichischen Littorale. *Wien. Ent. Zeit.* XII, pp. 89–108.

—— (1894). Die Dipteren von Steiermark. II Theil. *Mittheil. d. Nat. Ver. für Steierm.* XXX, pp. 1–152.

SURCOUF, J. M. and GONZALEZ-RINCONES, R. (1912). *Essai sur les Diptères Vulnérants du Venezuela.* Deuxième Partie, pp. 240, 100 figs. Paris.

TOWNSEND, C. H. TYLER (1893). *Notes from the Museum, Institute of Jamaica*, Nov. 22, no. 70.

—— (1893 *a*). A bot-like Anthomyid, parasite of a bird. *Journ. Instit. Jamaica*, I, pp. 381–382.

—— (1894). The grass-quit bot, an Anthomyid parasite of nestling birds. *Ibid.* II, pp. 173–174.

—— (1895). Contributions to the Dipterology of North America. II. *Trans. Am. Ent. Soc.* XXII, pp. 55–80.

—— (1916). On Australian Muscoidea, with description of new forms. *Insec. Insc. Menstr.* IV, pp. 44–45.

TOWNSEND, C. H. TYLER (1919). New genera and species of Muscoid flies. *Proc. U.S. Nat. Mus.* LVI, pp. 541–592.

VERRALL, G. H. (1886). A hundred new British species of Diptera. *Ent. Monthly Mag.* XXII, pp. 179–182, 199–202, 230–234.

VILLENEUVE, J. (1910). Notes synonymiques sur quelques Diptères—Types. *Deutsch. Ent. Zeitschr.* pp. 311–313.

—— (1911). Notes diptérologiques. I. Sur le genre *Phormia* R. D. *Wien. Entom. Zeit.* XXX, pp. 84–85.

—— (1913). De quelques Tachinaires à grande extension géographique. *Feuille des jeunes Natur.* XLIII, pp. 131–132.

—— (1915). Diptères nouveaux d'Afrique. *Bull. Soc. Ent. Fr.* LXXXIV, pp. 225–227, fig.

—— (1918). Sur *Phormia sordida* Zett. *Ibid.* no. 10, pp. 158–159.

WASIELEWSKI, T. VON and WUELKER, G. (1918). Die *Haemoproteus*-Infektion des Turmfalken. *Beih. zum Arch. f. Schiffs-. u. Tropen-Hyg.* XXII, pp. 117–212, 4 pls., 11 figs.

ZETTERSTEDT, J. W. (1838). *Insecta Lapponica descripta.* col. 1140. Lipsiae, 1838–1840.

—— (1845). *Diptera Scandinaviae disposita et descripta.* Tomus quartus, pp. 1281–1738.

—— (1849). *Ibid.* Tomus octavus, pp. 2935–3366.

—— (1859). *Ibid.* Tomus tredecimus, pp. 4943–6190.

DESCRIPTION OF A BOX FOR COLLECTING AND TRANSPORTING LIVING INSECTS, ETC.

By E. N. PAVLOVSKY, M.D., Sc.D.,

Professor at the Military Academy of Medicine, Petrograd.

(With 6 Text-figures.)

When collecting small living animals, particularly insects or other small Arthropods, for dissection, or search for parasites, etc., one encounters difficulties in choosing a suitable and convenient arrangement in which the animals may be kept without injuries until they are brought home. The usual entomological corked glass tubes and wide-mouthed jars with a gauze cover are not practicable when a large number must be carried; their bulk hinders free movement, and their fragility renders it necessary to pack them carefully in a box or other suitable containers.

In the summer of 1911, I was shown, at the Natural History Museum, Simpheropol, a very convenient apparatus for the collection and dispatching of Arthropods, which had been sent from Uriev by Prof. K. K. Saint-Hilaire. Unfortunately, I have not been able to discover the name of the inventor of the original model, a description of which I have never met with in the literature. Having convinced myself, during four years' experience of its use, of the valuable qualities of this apparatus, I have made some alteration in its construction, which I believe will render its application wider, and have decided to publish a description. If ever I should succeed in discovering the name of the author of the original model, I shall publish a supplementary note to that effect.

The model received from Prof. Saint-Hilaire consisted of a flat wooden box, 48·5 cm. in length, 34·5 cm. in breadth, and 5·5 cm. in depth. The interior of the box was divided, by eight longitudinal and five transversal partitions, into 40 rectangular compartments (Fig. I). The bottom of the box was formed of a sheet of wire gauze of 0·5–1 mm. mesh, while the lid was constructed and firmly fixed to the frame of the box. In the wood at points corresponding to the centre of each of the 40 compartments a circular aperture, 2·8 cm. in diameter, had been bored. Each of these openings was closed with a cork. The apparatus, as described, is very convenient for collecting and transporting Arthropods of cannibal habits, *e.g.* spiders, scorpions, myriapods,

etc., while the conditions of ventilation of the inner chambers are such as to render it a safe means for the transport of sensitive insects, as bumble-bees and other Hymenoptera, which will survive imprisonment in such a box much longer than in glass jars with gauze lids. In the summer 1914 I brought scorpions from Algeria and Tunis to Petrograd. The scorpions remained in the boxes from the 7th of July until the 28th of August, and the percentage of individuals which succumbed was very small, notwithstanding the unfavourable conditions of the voyage.

In order to render the apparatus of wider application I have made some modification in its structure which I now proceed to describe.

The external dimensions of the improved box are: length 45 cm.; breadth 31 cm.; and depth, including thickness of lid, 5·5 cm. The internal depth of the box is 4·6 cm. as in the original model.

The wooden lid is in three sections which are hinged and can be opened independently of each other (Fig. III). Each section is fastened by a pair of hooks screwed to the front wall of the box, suitable pins or eyelets being fixed into the edge of the lid for the hooks to engage (Fig. II). For greater security an additional hook is fixed at each end of the box.

The interior of the box is divided by eight continuous fixed transverse partitions (Fig. III, *F*) with equidistant vertical slots for the reception of quadrangular pieces of wood which divide those spaces between the continuous partitions into six compartments; space slots at the ends of the continuous partitions (Fig. III, *D*) serve for the reception of the quadrangular movable partitions when it is desired to increase the capacity of a compartment by the removal of one of these. If desired, pieces of tin plates may be used in place of wood for the movable partition, but in this case, the slots in the continuous partitions must be cut to fit accordingly. With all the movable partitions in their usual positions, the box is divided into 54 compartments each measuring 4 cm. × 4 cm. × 4·6 cm. In Fig. III the endmost series of compartments shows a replacement of the movable partition which results in the formation of two double compartments (*C*) and two single compartments. Such double compartments are suitable for the reception of solpugids or large scorpions. By further replacement it is possible to obtain compartments of triple capacity or more, and by removing all the movable partitions of one transverse compartment, space available for the reception of lizards, etc. may be obtained. The lid of the box is furnished with apertures (*M*) closed with corks, like that of the original model. The desired arrangement of the movable partitions should be made before the specimens are placed in the box and the latter should be introduced through one of the openings by removing the cork. It is obvious that no section of the lid should be opened when the corresponding part of the box already contains specimens.

The floor of the box is formed of wire gauze, as in the original model, and may be secured in position by a fillet of wood running round the lower edges of the box and screwed to the lateral end walls (see Fig. IV).

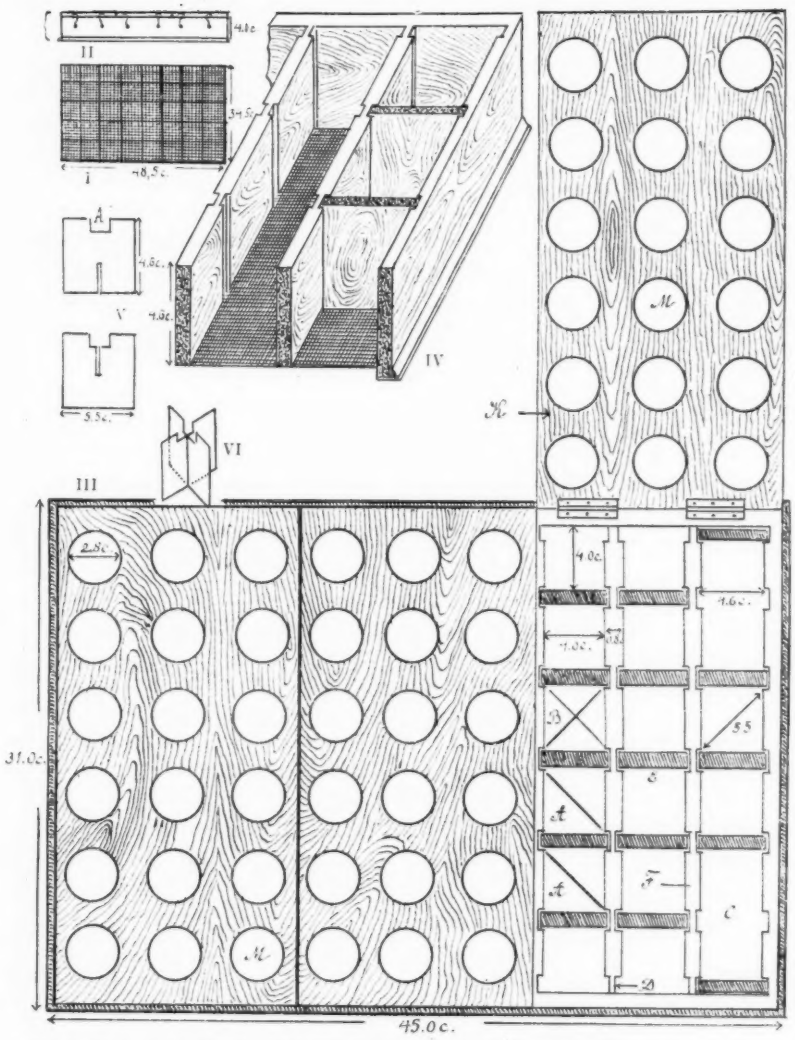


Fig. I. Bottom of original model, showing wire-gauze floor and partitions.

Fig. II. Lateral view of improved model showing hooks for fastening lid sections.

Fig. III. Plan of improved model showing lid sections, one of which is open: *A* and *B*, compartments subdivided into two or four parts respectively by the insertion of diagonal plates; *C*, double compartment formed by removal of one movable partition; *D*, space mortice; *E*, movable partitions; *M*, aperture of a compartment.

Fig. IV. Detail of the interior in perspective. The lid is not represented. The wire-gauze floor and wooden fillet are clearly shown.

Fig. V. Tin plates for diagonal partitions of compartments: *A*, incision for reception of part of cork protruding beneath the lid of the box.

Fig. VI. Pair of tin plates interlocked for fourfold subdivision of compartment.

The rectangular compartment of the box may be subdivided by the use of tin plates, cut to the suitable shape shown in Fig. V. These plates are inserted diagonally, either singly (Fig. III, *A*) or cross-wise in pairs (Fig. III, *B*). Such small compartments serve for the reception of small spiders, myriapods, ticks, etc. The broad incision in the upper edge of each of the diagonal division plates should be cut to fit closely to the part of the cork protruding through the aperture of the lid.

Several such boxes, placed one upon the other in such a manner that the gauze bottom of one rests upon the corks of the other, are bound with travelling straps for transport. For ordinary excursions a single box is usually quite sufficient and may be carried conveniently slung by a shoulder strap.

AN ACCIDENTAL INFECTION WITH *UNCINARIA*.

By FRED C. CALDWELL, S.B., M.D.,

State Director, International Health Board, Panama, Republic of Panama.

In the course of a study of a method for the recovery of *Uncinaria* larvae from the soil, one of the employees of the laboratory became infected under circumstances closely simulating experimental conditions. The history of the case is as follows:

On November 22, 1920, a quantity of faeces containing *Uncinaria* ova in large numbers was placed on the ground where it would be exposed to the sun and the rain. On December 8, many living larvae were recovered from the soil. These were placed in a tightly corked bottle out of the way on a high shelf, and all employees were warned that the specimen was not to be handled carelessly.

In spite of instructions, however, on December 11, one of the men took the specimen to demonstrate the larvae to some friends. While he was examining the preparation under the microscope, the fluid ran over the edge of the slide and came in contact with his hand. He is accustomed to hold the slide between the thumb and middle finger, allowing his hand at the base of the middle finger to rest upon the stage of the microscope.

Immediately after examining the specimen he became conscious of an intense itching at the tip of the thumb and tip and base of the middle finger.

On the following day, December 12, the three areas were inflamed and swollen and contained numbers of minute bright red points. There was no evidence of pus.

On December 13 the man noticed a marked tenderness under the arm in the region of the axillary glands. There was no evidence of lymphangitis, and the lesions on the hands remained the same as on the preceding day.

On December 14 a marked bronchitis developed. The stool was found to be negative for *Uncinaria* at this date and remained so for more than a month. Because he had been engaged as microscopist in our hookworm campaign in Panama, he had examined his stool many times during the previous year for ova of *Uncinaria*, with negative results.

The lesions on the hand had practically disappeared by December 24.

The stool was negative on January 10, 1921, but became positive for *Uncinaria* on January 17, thirty-eight days after the infection. On January 26 the ova were increased in number. The man left the city for the interior on January 26.

In answer to a request for information in regard to his condition in June, the following reply was received:

I have made other examinations and found several ova of *Uncinaria.* I am experiencing well-marked symptoms of the disease, such as general weakness, dizziness, and palpitation of the heart. My bronchitis is almost the same as when I left Panama. I have not as yet taken the treatment because of lack of time.

After repeated advice in regard to treatment, on October 31 I received the following letter:

When I received your telegram about treatment, I had already taken one treatment with chenopodium and collected the worms which were passed. I am enclosing a sample.

The sample mentioned contained about twenty hookworms. On November 15 the following statement arrived:

After a second treatment I was unable to find any worms. Repeated examinations for ova have been negative. I am now feeling quite well, except for palpitation of the heart.

From the above history it seems certain that in this case the larvae after passing through the skin, travelled up the lymphatics, through the axillary glands, into the blood stream and into the lungs in three days. The parasites had reached the intestines and had matured within thirty-eight days. One treatment with chenopodium had evidently sufficed to cure this particular case.

NOSEMA APIS AND *ACARAPIS* (*TARSONEMUS*) *WOODI* IN RELATION TO ISLE OF WIGHT BEE DISEASE.

By GEO. W. BULLAMORE,

Molteno Institute for Research in Parasitology, Cambridge.

CONTENTS.

		PAGE
I.	Some outbreaks of bee disease previous to 1906	53
II.	The outbreak of 1906 commonly called Isle of Wight Disease	55
III.	The symptoms of disease in adult bees	55
IV.	Attempts to ascertain the cause of Isle of Wight Disease	56
	A. *Bacillus pestiformis apis*	56
	B. *Nosema apis*	56
	C. *Acarapis* (*Tarsonemus*) *woodi*	58
V.	Conclusions	61

I. Some Outbreaks of Bee Disease previous to 1906.

In former times when this country was dependent upon bees for its supply of sugar, a heavy mortality among these insects was of sufficient importance to be placed on record. In his *Animal Plagues* Fleming (1871) gives a number of references to such losses. In Ireland there was a "mortality of bees" in 950 A.D. and again in 992 A.D. there was a "great mortality upon men, cattle and bees." In 1035 A.D. the destruction of bees afflicted the whole of Bavaria. An eclipse of the sun in 1124 A.D. was followed by a great pestilence amongst oxen, sheep, pigs, and bees. During the time of the "Black Death," also, there appears to have been heavy losses of bees and at the Manor Court of Heacham in Norfolk, a statement was made on oath by the steward in the forty-fifth year of the reign of Edward III (1372 A.D.) to the effect that ten out of eleven stocks of bees had perished from the murrain. There is little doubt that this entry in the manorial court rolls refers to epidemic disease, but, as Fleming points out, "there is evidently no relationship between the *morinâ* of the bees and that of the sheep and cows."

The year 1443 A.D. was rainy and tempestuous after May which "much hurted both bees and sheep in Ireland"; while in Italy in 1690 A.D. "bees extracting no sweetness from the calyces of the flowers, but a bitter poison, either died or left the country." A great mortality among bees and carp is also recorded in 1717 A.D. in Silesia.

A well-known writer on bees, Dr Bevan (1837), states that

> in the winter of 1782–3, a general mortality took place among the bees in this country, which was attributed to various causes; want of honey was not one of them; for in some

hives considerable store was found after the bees were gone. Some were of opinion that it arose from the preceding being a bad breeding year and thought that the bees died of old age. Others attributed it to the moistness of the spring of 1783 which rendered the providing of pollen difficult, for without pollen no brood can be raised....The fatal influence ascribed to the wetness of the spring of 1782 seems to be improbable; though it might have affected the quantity of bees bred, it was not likely to put a stop to their breeding altogether, and the young bees ought at any rate to have escaped the desolating evil, if it were old age alone; yet wherever the mortality once made its appearance, every bee became its victim.

In the early sixties of the nineteenth century the columns of *The Field* newspaper supply evidence of the existence of trouble which beekeepers of the day described in language almost identical with that used to describe the Isle of Wight disease at a later period. Occasional references to a similar trouble are to be found in the bee literature of this country until the beginning of the present century.

In other countries, also, epidemic bee disease may still be heard of from time to time. Berlepsch records that in the spring of 1859, after the bees had made good use of the sallows, wholesale losses took place. The bees were to be seen in heaps, their bodies swollen with watery excrement. Many stocks were one day healthy, the next day half were dead, and the day following that all the bees were dead. The disease appeared in many places about Easter, and in others not till Whitsuntide. It was similar to human cholera, ravaged the whole of south Hanover and the lands adjoining and even extended into Denmark.

According to Dadant (1907) during the years 1901–05 entire apiaries were depopulated in the province of Ancona, Italy, by mal de Maggio, a disease of the adult bee. The losses occurred just at the opening of the honey harvest.

In Australia, whole apiaries are at times extinguished from some disease the cause of which is unknown (Garrett, 1910).

In Brazil hundreds of stocks perish in March and April, the affected bees dying outside the hives. The beekeepers attribute the trouble to the poisonous properties of the nectar of certain plants which are in bloom at the time[1] (Hannemann, 1909).

In Canada and the United States epidemics occur and the following quotation from the American *Gleanings in Bee Culture* is an interesting description of virulent disease by Critchlow (1904):

Is this a new and strange bee disease, or is it a very malignant type of paralysis? Possibly some purely local cause is responsible for the great mortality among the bees. Who can give us some light? There seems to be great danger in Utah of a total loss of the entire bee industry. I shall give you as nearly as I can the conditions, both in the past and at the present time.

In this valley and in the one fifty miles north of here, called Cache Valley, there have been for many years a great many bees, both in the hands of skilled operators and in the

[1] Very many plants have come under the suspicion of beekeepers at one time and another in various parts of the world when there was no local spraying of fruit-blossom, etc., to which the losses could be attributed.

hands of many farmers and small owners. A year ago this spring there were upwards of 2000 colonies of bees lost. It was thought a year ago that it was owing to the very cold winter weather and changeable weather in the spring; but the strange part of it is that in some localities not any warmer, but if anything, colder, the bees survived all right, with scarcely any loss at all.

I lost last year 300 colonies of bees, and in some localities in Cache Valley there were upwards of 500 colonies that went under; and in this valley (Salt Lake) last year there were fully 800 colonies that perished. It was thought by all those who were interested that it was due to the hard winter and cold spring.

This writer, who had lost nearly all his stocks, bought 225 colonies in a district that disease had not visited, and moved them into his apiary. He continues:

I was there yesterday, and a large part of the entire 225 colonies are affected with what appears to be paralysis. While there is no trembling, they drop down in the grass in front of the hives, and are unable to fly; they seem to mount the grass and twigs with great difficulty, and in taking them up in my hands they were unable to fly away, and, if thrown into the air, would drop to the ground. They seemed to have no desire even to sting. It appears to be contagious, for it seems to affect a certain part of a row, while another section of the row seems to be strong and swarming. A number of hives have all gone under. The entire yard, of course, is exposed for the reason that a few, perhaps twenty, colonies from what were left of the lot last year were put with them without any thought of anything being wrong, except that they were weak.

I am fully satisfied now that the loss last year, which would number at least 2000 colonies in Cache Valley, was due entirely to this condition.

II. The Outbreak of 1906 commonly called Isle of Wight Disease.

In 1906 we first began to hear of the bees in the Isle of Wight suffering from "paralysis," a disease of world-wide occurrence and of which the cause is unknown. On account of the deadly nature of the Isle of Wight visitation, however, it was afterwards decided that the disease was a new one and the name of Isle of Wight disease came into use. It was found to have been present on the Isle of Wight in 1904, so it was consequently assumed to have then originated and to have spread thence to the mainland. It usually manifested itself by the presence in the apiary of numbers of crawling bees with their abdomens distended with undischarged faeces. In a few months all the colonies in the apiary were dead.

III. The Symptoms of disease in Adult Bees.

The whole subject of bee diseases teems with difficulties, and it is improbable that any method of differentiating them other than the demonstration of the causal organism is likely to prove of value. Inability to fly, which is the chief symptom in any disease of the adult bee, may originate from a variety of causes, *e.g.* the ingestion of fungi, mineral poisons, fermenting honey, syrup or fruit juice, or from weakness due to starvation.

Inability to fly leads to a retention of the faeces, which are voided normally by the bee in the open air while flying. We find that a crawling bee may be

slow and sluggish, may run rapidly, may tremble, present a hairless appearance, drag its hind pair of legs helplessly, may be subject to dysenteric discharges, or may impart a yellow colour to the interior of the hive by passing constantly a tiny threadlet of faeces. Possibly the varying manifestation may be due to the multiplication of bacteria of different species or of other parasites in the bowel of the affected bee. Whether the condition is sometimes due to infection it is impossible to decide.

Again, the normal life of the individual bee may vary from eight weeks to as many months according to the activities of the colony, and it may be that organisms which do little harm in two months cause serious trouble where the necessities of the colony require the extension of the lives of its individual members for a longer period.

The difficulty of tracing a connection between a disease and any parasitic organism that may be found in the bee becomes very real when the investigation of disease is attempted. If, while the external conditions are favourable, the organism is fed to a colony as an experiment, the bees may fail to die or to develop symptoms; while if unfavourable conditions prevail at the time of the experiment, death may be due to unrecognised causes, such as infection with *N. apis* (see below). Apparently healthy bees, if prevented from flying, will sometimes develop symptoms (crawling with bowel distention) indistinguishable from Isle of Wight disease.

IV. Attempts to ascertain the Cause of Isle of Wight Disease.

A. *Bacillus pestiformis apis.*

The first to associate a definite causal organism with Isle of Wight disease was the late Dr Walter Malden (1909). He found no macroscopic appearances in the diseased bees that were not to be found in bees from healthy colonies. Microscopically, "no changes were discovered in the salivary glands, brain, fat-body, heart, tracheae, air-sacs, Malpighian bodies, or honey stomach." Changes were found in the chyle stomach, however, and attention was concentrated on that organ. In film preparations made from small portions of the chyle stomachs of diseased bees, teased out on glass slides and stained with methylene blue, a bacillus was found with darkly staining ends and a lightly staining central band, resembling *Bacillus pestis* in general appearance. This was suggested as having a causal relationship to the disease and the name *Bacillus pestiformis apis* was proposed. Cultures of this bacillus fed in sugar to bees did not appear to have any harmful effect and the view that it is the organism that caused the disease has been abandoned.

B. *Nosema apis.*

In 1907 Dr Enoch Zander (1911) discovered a protozoon in bees which was recognised as being closely related to *Nosema bombycis*, a parasite which did enormous damage to the silkworm industry in France about the middle

of the nineteenth century. The organism found in bees was named *Nosema apis* and Zander looked upon it as the cause of heavy losses in Bavaria. The essential feature of the trouble was a sudden and extensive mortality among the bees inside and outside the hive. Dysentery was an occasional accompaniment. Berlepsch's description of the epidemic of 1859 (see p. 54) is considered by Zander to be a typical description of the ravages of unchecked *Nosema* disease.

The discovery attracted considerable attention. Maassen (1911) found *Nosema* to be widely prevalent in German apiaries, but although he looks upon the parasite as pathogenic he considers that unfavourable conditions are necessary for the manifestation of disease.

Nussbaumer (1912) found *Nosema* in association with heavy losses in Switzerland.

Beuhne (1916) states that *Nosema* was first discovered in Australia in 1909, but that observation showed that it was

> doubtful whether the presence of the parasite is in itself necessarily fatal, or that it greatly interferes with the productiveness of the hives excepting under certain conditions due to climatic influence....In fact under ordinary conditions the disease is endemic, and becomes epidemic only when the vitality of the bee is impaired by the malnutrition during the bees' larval development which is caused by a dearth, or the inferior quality of the nitrogenous food which bees obtain solely from the pollen of the flowers of plants.

As the result of investigation at Cambridge (Graham-Smith, Fantham, Porter, Malden, and Bullamore 1912) a report was issued showing that *Nosema* was present in a large percentage of stocks affected with Isle of Wight disease and the disease was attributed to the presence of this parasite.

Later, Anderson and Rennie (1916) working on the Isle of Lewis took up the question of *Nosema* and Isle of Wight disease. They were unable to corroborate the findings of the Cambridge investigation and state that *Nosema* was found to be present in stocks without disease symptoms appearing. They did not find *Nosema* distributed in the bees of all the stocks but only in a few stocks at any one time, and when it occurred "Isle of Wight disease was not present."

The result is somewhat surprising as, assuming that *Nosema* is a comparatively harmless parasite, its non-occurrence in stocks suffering from Isle of Wight disease seems to require some explanation.

While the work on the Isle of Lewis was being carried on, continuous importations of bees were being made from all parts of the country. Bees, assumed to be healthy, were introduced into the apiary from Scotland, England, Wales, Ireland, America, Switzerland, Austria, and Holland. These bees developed crawling symptoms at periods varying from a week to a month or more after arrival. Consequently it is difficult to determine the disease with which Anderson and Rennie were actually working or to feel sure that importations of other diseases were not being made. The following are the particulars of what is described as a spontaneous recovery.

Three stocks of bees, one Italian, one Carniolan and one black (British or Dutch?) were imported into the apiary from Devonshire on June 4th, 1915.

During June these three stocks gave off four swarms and the seven colonies were showing crawling symptoms on June 30th. Three of the colonies died owing to faulty queens and another was destroyed by robber bees. A fifth was reinforced by the addition of three pounds of bees (source not stated) and an Italian queen was also given to this colony. Some driven bees from Wales were placed in the apiary. In December, 1915, there were four stocks alive showing no signs of disease.

Accounts of further work by Dr Rennie and Miss Harvey (1919 A and B) are given in the *Journal of the Scottish Board of Agriculture*. With regard to *Nosema* the conclusion arrived at is that it "is always a weakening factor, and in the presence of other adverse conditions favourable to the development of dysentery it may become seriously pathogenic to bee stocks." In ordinary circumstances it was not found to destroy colonies in the rapid and virulent manner generally found in Isle of Wight disease. The authors consider that in the latter disease there is no recovery of sick bees nor of affected stocks.

Mention is also made of a temporary sickness which sometimes affected all the bees of a district. "In such cases it would appear to be due to some disturbing factor in the nectar or pollen."

C. *Acarapis* (*Tarsonemus*) *woodi*.

In November, 1920, a paper was read before the Royal Society of Edinburgh in which Dr Rennie, in association with Mr Bruce White and Miss Harvey, described a new species of mite from the tracheae of hive bees. This mite, which was named *Tarsonemus woodi*, was put forward as being the cause of Isle of Wight disease, which was henceforth to be known as "acarine disease." Hirst (1921) considers that the new mite differs sufficiently from *Tarsonemus* to form a new genus and proposes that the species shall be renamed *Acarapis woodi*.

The mites gain entrance to the tracheae by means of the first pair of thoracic spiracles. Crawling of bees, followed by the death of the affected colony then takes place. The presence of the mite is not necessarily fatal however, for we read in the *Report* to the Royal Society of Edinburgh that

> Of 140 stocks believed by their owners to be healthy, 50 or nearly 36 per cent. harboured the parasite. Concurrent with such discoveries we ascertained by direct examination ourselves of flying bees, (1) which were members of colonies in which the disease was definitely established and (2) which were taken from colonies believed to be healthy and showing no indications otherwise, that amongst these were to be found considerable numbers harbouring the parasite. This was further complicated by the fact that in those infected flying bees certain of those pathological conditions—*e.g.* the blackening and hardening of the tracheal tubes—were very marked. As an example it may be quoted that this condition was found in bees entering the hive carrying pollen or nectar, both belonging to stocks in which crawling and other symptoms were well established and also in those reputed healthy stocks.

In the record of another stock we read that "the flying workers were frequently more heavily parasitised than were the bees of the same stock which were unable to fly."

In an interesting case which was under the writer's own observation in April, 1921, the crawling symptom was manifested but no mites were to be found. The crawling disappeared during the summer but reappeared in the autumn when the symptom was accompanied by the presence of mites in the tracheae.

As an example of the recovery of a stock we have the following from a letter received by Dr Rennie (1921):

> On January 9th I received your report that the bees from one of my stocks had *Tarsonemus woodi*.
>
> From this stock reported diseased on that date I had a swarm on the 23rd of May and this swarm swarmed on the 28th of June. I have taken off 150 sections and have three very strong stocks.

Dr Rennie's explanation is that early diagnosis enables us to recognise such recoveries and that formerly this was not possible. We only recognised the presence of the disease after it was irretrievably established. This "gave us an erroneous idea as to the gravity of the disease."

Such an explanation is not altogether satisfactory. When Isle of Wight disease reached an apiary the loss of colonies was usually 100 per cent. and the margin of error in forming an estimate of its gravity must have been very slight.

In the *Report* of the Hants and Isle of Wight Beekeepers' Association for 1906 we read:

> Twenty-five years' acquaintance with bees, bee men and bee life has not revealed anything so deadly or mysterious as this so-called bee paralysis of the Island.

Silver (1907), who toured the Island in 1907, gives his impressions in these words:

> The sight of whole apiaries of 10 to 20 hives standing desolate and deserted in the middle of May is a most distressing one, and standing as I did, under a horse-chestnut tree in full blossom, in the grounds of the Rev. John Vicars, of Colbourne, situated in the centre of the Island, not a bee was visible on a beautiful spring day.

Complete apiaries died out in May and June just after swarming and when the hives must have been tenanted with young bees.

In support of the thesis that *Tarsonemus woodi* has been entirely responsible for the losses known as Isle of Wight disease, Dr Rennie suggests that *T. woodi* is at present a parasite of bees in this country only. He assumes that Isle of Wight disease has never been clearly shown to exist in any other country and that no such persistent losses have ever occurred before in this or any other country, and discusses the possibility that a new disease has arisen through the migration of the mite from some other insect to the hive bee as host.

The evidence that the mite is not to be found in bees of other countries is confined to the negative results obtained by the examination of a few

hundred bees that have accompanied queen bees sent to this country by post. But if the mite is the cause of a serious disease its occurrence in such bees would be rare. It is in the dwindling and unprofitable apiaries of other countries that search must be made, and until we get definite statements from foreign workers that the mite cannot be found in any of the troubles classed together as paralysis, the chances are in favour of its occurrence.

As to the long duration of Isle of Wight disease as compared with any other epidemic, we have no knowledge as to the number of years that apiaries have been re-stocked where paralysis is causing annual losses. In this country steady losses were formerly confined to districts. That such losses now occur all over the country is due to the altered method of beekeeping. And is it safe to assume that such losses have always been due to the same cause for the last seventeen years in this country and to some other cause in the various countries from which we have imported bees? Since Isle of Wight disease was first reported nearly all the bees of this country have disappeared. Their places have been taken by foreign bees, many of which have also died and the present bees of this country are mainly the descendants of recent importations from various parts of Europe, Asia, Africa, and America.

The German epidemic of 1859 followed the importation of foreign bees.

Our own losses in the early sixties of the last century came shortly after we commenced to import foreign bees and had started a crusade against the sulphuring of weak and redundant stocks. Prior to the starting of the epidemic in the Isle of Wight that island was a beekeepers' paradise, where the bees increased and gave surplus with little or no assistance from their owners. Nearly every village contained a number of skep beekeepers whose surplus colonies were sulphured in the autumn or exported as driven bees. With modern methods a steady importation of foreign bees took place. From 1898 to 1904 stocks and queens of foreign races were imported into the district where the disease is supposed to have originated. All the bees in that district were destroyed and the epidemic advanced across the island. Imms (1907) states that he was informed that the disease was so virulent that healthy swarms imported from the mainland were badly diseased within a week[1].

Importations of foreign bees have been so heavy and continuous that it is difficult to believe that no diseases have been introduced with these bees during the present century. In reviewing the work that has been done on Isle of Wight disease in Scotland, the possibility suggests itself that at one time

[1] The danger from trading and consequent intermixing appears to have been thoroughly grasped by our forefathers who recognised that it was unlucky to trade in bees.

The monks were great beekeepers and their migrations with their bees appear to have brought much bad luck. The traditional ceremonies that have been handed down among peasant beekeepers are often of pagan origin. The connection between Christianity and lack of honey is well shown in an old German adage given by Langstroth (1868):

"Bells' ding-dong and choral song
Deter the bee from industry;
But hoot of owl and wolf's long howl
Incite to moil and steady toil."

what may have been a bacterial disease was being investigated as the Isle of Wight disease[1].

Tinsley (1918), in a bulletin issued by the West of Scotland College of Agriculture, states that he succeeded in infecting healthy bees with Isle of Wight disease by feeding them with sugar syrup in which the liquid contents of the intestines of sick bees had been incorporated. In one of Dr Rennie's earlier experiments (1919 A) *Nosema* spores in candy were fed to healthy bees in May. Crawling without *Nosema* was recorded as being present in June and the bees were found dead the following January. In 1915 also, pulped diseased bees were fed in honey to a stock on June 28th. The stock swarmed and both lots showed crawling in October and died out. The nearest bees were two miles away and remained healthy (Anderson and Rennie, 1916).

We assume that the *Nosema* spores were obtained from sick bees and that bacteria and other organisms were therefore unavoidably present in the candy. The results obtained by Dr Rennie may thus have been due to the organism that was present in the cases recorded by Tinsley. That organism is unknown, but the results suggest that it was situated in the alimentary canal.

V. CONCLUSIONS.

Acarine disease appears to be less virulent than the disease which swept across the Isle of Wight in the early years of this century. That the mite was causing damage at the same time is very probable but the investigations were centred on the acute and virulent disease.

It may be that most of the stocks affected with mites, but showing no symptoms of disease, die out sooner or later. But this does not demonstrate the existence of a new disease. It merely emphasises the soundness of the older system of beekeeping which considered it undesirable to retain any stock after the third season, the less desirable colonies being sulphured at an earlier period.

Although it may not be the cause of the Isle of Wight disease the discovery of the mite is of economic importance, revealing, as it does, one of the causes of the failure of modern beekeeping. Ever since the introduction of the "humane" system which saved the redundant bees and distributed them as "driven bees" throughout the length and breadth of the land, there has been a steady increase in disease which has helped to render the industry of honey production an unprofitable one. Before the rise of the Isle of Wight epidemic the losses were attributed usually to foul brood, although there was

[1] The difficulty in classifying bee disease by symptoms is well shown by the following instance. While the work on *Nosema* in its relationship to Isle of Wight disease was being carried out at Cambridge there ensued a heavy mortality of humble-bees which was found to be associated with the presence in the Malpighian tubes of a protozoon closely resembling *Nosema*. In the year immediately past a similar mortality has been noticed in humble-bees, but the protozoon could not be found. The organism accompanying the mortality in 1921 was a nematode worm *Sphaerularia bombi* which undergoes development in the body cavity of the bee and eventually gives rise to huge numbers of larvae. In both years, the symptom of the trouble was inability to fly.

much difference of opinion as to the amount of harm caused by this latter malady. It is possible that *Tarsonemus* was present in the more severe cases and, consequently, a fresh series of observations are necessary.

It is the opinion of the writer that the mite will prove a comparatively harmless parasite in countries where two or more honey harvests and constant breeding activity are the rule. In some such districts we may expect to find the endemic centres of the disease.

If this opinion is confirmed, the mite will also be found in Australia, America and other countries as it is unlikely that we have been the only country to import it. In America there is a large amount of unexplained paralysis, and of winter and spring losses, while in Australia the subject of bee mortality is much discussed without anything very definite being known. Some of these troubles may be accompanied by mites.

In this country bees parasitised by mites are to be found all over the kingdom from Land's End to John o' Groats. The recognition of the dangers arising from modern procedure may eventually give rise to wiser and better methods of beekeeping and the discovery of the Aberdeen investigators may thus have far-reaching and unforeseen consequences.

REFERENCES.

ANDERSON, J. (1916). The connection of *Nosema apis* and "Isle of Wight" Disease in Hive Bees. *Proc. R. Physical Soc. of Edin.* XX, 16.

ANDERSON, J. and RENNIE, J. (1916). Observations and Experiments bearing on Isle of Wight Disease in Hive Bees. *Ibid.* XX, 23.

BERLEPSCH, BARON VON (1869). *Die Biene und ihre Zucht.* Mannheim.

BEUHNE, F. R. (1916). *Nosema apis* in Victoria. *Journ. of the Dept. of Agric. of Victoria,* XIV, 629.

BEVAN, E. (1827). *The Honey Bee.* London.

CRITCHLOW, B. P. (16. vii. 1904). *Gleanings in Bee Culture Medina, Ohio,* XXXII, 692.

DADANT, C. (1907). *Langstroth on the hive and Honey Bee.* Revised by Dadant. Illinois, U.S.A.

FLEMING, G. (1871). *Animal Plagues.* London.

GRAHAM-SMITH, G. S., FANTHAM, H. B., PORTER, A., MALDEN, W. and BULLAMORE, G. W. (1912). Report on the Isle of Wight Bee Disease (Microsporidiosis). *Supplement No.* 8, *Journ. of the Bd. of Agric.* XIX.

HANNEMANN (1909). Cited by Zander (1911).

HIRST, S. (1921). On the mite *Acarapis woodi* (Rennie) associated with the Isle of Wight Bee Disease. *Annals and Mag. of Nat. Hist.* Ninth Series, No. 42, 509.

LANGSTROTH, L. L. (1868). *On the Hive and Honey Bee.* Third Edition. Philadelphia. See also Dadant (1907).

MAASSEN, A. (1911). Zur Aetiologie und Epidemologie der Ruhr bei den Bienenvölkern. *Mitteilungen a. d. K. Biolog. Anstalt f. Land- und Forstwirtschaft,* 50.

MALDEN, W. (ii. 1909). Further Report on a Disease of Bees in the Isle of Wight. *Journ. of the Bd. of Agric.* XV, 809.

NUSSBAUMER, T. (1912). Einige Erfahrungen Über die Nosemakrankheit. *Schweizerische Bienenzeitung* (Reprint).

RENNIE, J. and HARVEY, E. (1919 A). Isle of Wight Disease in Hive Bees. *Journ. of the Scottish Bd. of Agric.* II, 176.

—— (1919 B). *Nosema apis* in Hive Bees. *Ibid.* II, 511.

RENNIE, J., WHITE, P. B. and HARVEY, E. (1920). Isle of Wight Disease in Hive Bees. *Trans. Roy. Soc. Edin.* LII, 737.

RENNIE, J. (1921). Notes on Acarine Disease. *Bee World,* III, 117.

SILVER, J. (1907). Bee Disease in the Isle of Wight. *Irish Bee Journal,* VII, 10.

TINSLEY, J. (1918). Preliminary Report on the Isle of Wight Bee Disease. *Bulletin* 85 *W. of Scotland Agric. Coll. Glasgow.*

ZANDER, E. (1911). *Handbuch der Bienenkunde.*

THREE NEW SPECIES OF *TRICHODECTES* FROM *CEPHALOPHUS MONTICOLA* AND *PROCAVIA CAPENSIS* FROM SOUTH AFRICA.

By LAURENCE HILL.

(*Pietermaritzburg, Natal.*)

(With Plate II.)

Trichodectes bedfordi, n.sp. Plate II, figs. 1–3.

Numerous males and females collected from a Blue Duiker (*Cephalophus* (Guebei) *monticola*) at Ngome Forest, Mt Ngwibi, Natal, by Mr J. Tustin.

Female. Total length 1·73 mm., length of head 0·37 mm., length of prothorax 0·09 mm., length of metathorax 0·11 mm., length of abdomen 1·16 mm. Width of head 0·30 mm., width of prothorax 0·25 mm., width of metathorax 0·30 mm., width of abdomen 0·42 mm.

Head. Longer than broad. Forehead elongated with a moderately deep median notch, which has a deep marginal band of chestnut-brown chitin divided into two parts by a narrow median longitudinal split, and produced into prominent trabecula-like processes in front of each antenna. General colour of head a pale yellowish-brown, with deep chestnut mandibles and bands. Antennal sinuses rather small and shallow. Ocular projections extending only very slightly beyond the temples, which are rounded. Temples with two short widely spaced hairs. Occipital margin slightly convex, rounded at the points where it is met by the faint occipital bands. Antennal bands of medium width, not reaching the base of the antennae, and tapering towards the anterior margin of the head, then broadening out into a wide clear space, interrupted by a deep narrow longitudinal line. Occipital bands joining the antennal bands just in front of the trabecula-like processes. Antenna long and narrow, extending well beyond the posterior margin of the head; third joint the longest; first and second joints of equal length. Eye pronounced. On the dorsal surface of the forehead there are three short pustulated hairs situated in a straight transverse line on each side near the antero-lateral margin of the head.

Thorax. Same colour as the head. Pronotum bare, with sides diverging, and a broad chestnut band at the lateral margins. Metathorax as wide as

the head, sides diverging, and rounded at the postero-lateral margins, with a broad band at the lateral margins and three small pustulated hairs on each side in a transverse line near the postero-lateral margins.

Abdomen. Elongated and narrow, white in colour, with crenulated lateral margins. Segments widely diverging towards postero-lateral borders, and with a yellowish-brown transverse band on the dorsal surface of each segment. On the dorsal surface, at the posterior margin of the band on first segment, one short pustulated hair on each side of the meson; last segment bilobed at the apex, with three to four median hairs on each lobe, and with a pair of short pustulated hairs situated on each side just within the lateral margin, and another pair mid-way between these towards the posterior indentation; remaining segments with a transverse row of minute pustulated hairs; segments two to seven with a small spiracle at each lateral angle.

Male. Total length 1·56 mm., length of head 0·40 mm., length of prothorax 0·07 mm., length of metathorax 0·14 mm., length of abdomen 0·95 mm. Width of head 0·28 mm., width of prothorax 0·22 mm., width of metathorax 0·26 mm., width of abdomen 0·43 mm.

Head. With the median notch deeper than that of the female. Antennal sinuses deep. Ocular projections small, not well defined. Temples narrow, smoothly rounded. Occipital margin markedly convex, emarginate where it is met by the occipital bands. Eye pronounced. Antennae large, and backward pointing, reaching the metathorax; the first joint large and wide (saculated) longer than the second and third joints combined; second and third joints of approximately equal length; on the upper surface of the first joint of the antenna, a longitudinal row of eight small pustulated hairs one beside the other, and extending from the proximal to the distal extremity; third joint slightly curved, and at the distal end two or three short stout dark-brown denticles. Mandibles situated well forward on the head.

Abdomen. Closely resembles the female in general outline, with the last segment oval, and having a row of medium sized hairs at the tip. On the dorsal surface, the transverse brown bands of segments four to seven are deeper (somewhat telescopic in appearance), and with well marked projecting somewhat rounded edges almost reaching the spiracles at the lateral angles. (Fig. 3 gives an excellent representation of these bands.)

Genitalia. Very conspicuous. The basal plate longer than the parameres, and consisting of two thickly-chitinised bars slightly thickened and rounded at their posterior end. Parameres long and narrow, of even thickness throughout their length (concavo-convex in shape), and markedly diverging posteriorly. Penis long and stout. Beneath the penis a wedge-shaped plate with the posterior end bifid. (Plate II, fig. 3.)

This species would seem to be closely allied to *Tr. lineatus* n.sp., described by Bedford in Part II, *Anop. from South African Hosts* (1920). The shape, however, of the abdominal segments of both male and female, and

terminal segment and genitalia of the male enables this species to be readily distinguished from that described by him.

My thanks are due to Mr G. A. H. Bedford of the Veterinary Research Laboratories, Onderstepoort, Pretoria, for the kindly help and assistance which he has always been most ready to give me, and I have great pleasure in naming this species after him.

Trichodectes lindfieldi n.sp. Plate II, figs. 4–6.

Numerous males and females taken from a Cape Hyrax (*Procavia capensis*) shot at Mtabamhlope, Estcourt District, Natal, by Mr P. Barnes.

Female. Total length 1·47 mm., length of head 0·43 mm., length of prothorax 0·12 mm., length of metathorax 0·15 mm., length of abdomen 0·77 mm. Width of head across temples 0·42 mm., width of prothorax 0·30 mm., width of metathorax 0·40 mm., width of abdomen, at third segment 0·71 mm.

Head. Light yellowish-brown. Almost as broad as long. Forehead dome-shaped, emarginated in front, with the sides slightly convex, and produced with a prominent trabecula-like process in front of each antenna. Antennal bands narrow and dark, terminating approximately midway between the anterior margin of the head and the trabecula-like processes. Frontal sinus deep, semicircular in section, with a marginal band of dark brown chitin divided into two parts by a median longitudinal narrow space; one hair situated on each side just within the emargination. Antennal sinuses small and shallow with rounded inner margin. On each side of the forehead, there are three hairs, one in front, one in the middle, and one above the antennal sinus. Ocular projections prominent, extending well beyond the temples which are rounded. Occipital margin slightly convex, very slightly emarginate at the points where it is met by the occipital bands. Temples rounded with a narrow dark marginal band and three short marginal hairs. Occipital bands conspicuous, connected at their bases by a broad band, and meeting the antennal bands just above the trabecula-like processes. Antennae long and slender, reaching beyond the posterior margin of the head; the third segment the longest with four minute hairs; first and second segments of equal length each with two short hairs. On the dorsal surface of the forehead there is a semicircular row of six small pustulated hairs; and below this semicircular row one small hair on either side just within the antero-lateral border; also two small and two medium hairs situated in a line with the trabecula-like processes. On the hind-head a semicircular row of four short hairs in the middle, and two on each temple.

Prothorax. Much broader than long, with a broad marginal band of deep chestnut-brown; lateral margins almost parallel, the posterior margin markedly convex, with medium postero-lateral emarginations, and one short pustulated hair on each side of the meson near the anterior margin.

Mesothorax. With three pustulated hairs on the dorsal surface.

Metathorax. Wider than prothorax, with prominent projecting lateral angles reaching nearly as far as the postero-lateral angles of the first abdominal segment. On the dorsal surface two longish hairs at each lateral angle, and a row of fourteen small hairs along the posterior margin. Posterior margin markedly concave.

Abdomen. Crenate, somewhat longer than wide, widest at the third segment, with a median dark transverse band on all the segments. On the first three segments there is a large dark brown pleurite on each side, these are succeeded on the remaining segments by a smaller pleurite of the same colour. On the dorsal surface, the first segment has two pairs of small pustulated hairs on each side of the meson near the anterior margin, and twelve hairs in a row along the posterior margin; second segment with a transverse row of twenty small pustulated hairs along the posterior margin; and a lateral group of five hairs. Above, and on the inner side of this lateral group, there is a further distinct separate group of three hairs; third segment with a transverse row of twenty hairs along the posterior margin, a lateral group of five hairs, and on the inner side above each lateral group, a further group of five hairs; fourth segment with a row of twenty-four pustulated hairs, a lateral group of three hairs, and on the inner side of this group a pair of hairs; fifth segment with a transverse row of twenty-four pustulated hairs, and a pair of hairs just within the lateral margin; sixth segment with a continuous row of thirty-six pustulated hairs; seventh segment with a row of twenty-four hairs; last segment bilobed at the apex, with a transverse row of twelve hairs, and two small and two longish hairs on each lobe.

On the ventral surface segments one and two each with a row of twelve hairs; segment three with a row of fourteen hairs; segment four with a transverse row of thirty-two hairs divided into three groups, the median group consisting of twenty hairs, and each lateral group of six hairs; segment five with a row of thirty hairs, the median group consisting of twenty hairs, and each lateral group of five hairs; segment six with a row of twenty-eight hairs, the median group of twenty hairs, and each lateral group of four hairs; seventh segment with a pair of small pustulated hairs at each lateral margin; last segment with nine to ten minute pustulated hairs scattered on each side of the meson.

Male. Total length 1·52 mm., length of head 0·39 mm., length of prothorax 0·12 mm., length of metathorax 0·15 mm., length of abdomen 0·86 mm. Width of head across temples 0·39 mm., width of prothorax 0·28 mm., width of metathorax 0·35 mm., width of abdomen at third segment 0·63 mm.

Head. The general outline of the head mostly resembles that of the female. The antennal sinuses are deeper and wider. Ocular projections scarcely visible. Temples bluntly rounded, meeting the occipital margin at an angle. At the posterior margin of the temples there is a small prominent chitinised protuberance (absent in the female). Antennal bands broader than in the

female, becoming fused into the occipital bands in front of the trabecula-like processes. Antennae large, and directed backwards, reaching well beyond the occipital margin of the head; the first segment broad, and longer than the second and third combined; second segment longer than the third. On the hind-head a semicircular row of four small pustulated hairs, and three on each temple.

Prothorax. With lateral angles bluntly rounded.

Abdomen. Oval, widest across the third segment. Resembles the female in regard to colour, shape of pleurites, etc. On the dorsal surface, last segment with a semicircular row of twelve pustulated hairs, and two small hairs at the posterior margin.

Genitalia. Conspicuous, the basal plate consisting of two chitinous bars considerably longer than the parameres. Parameres consist of short bands, broad at the base where they are rounded, and narrowing posteriorly, becoming fused at the tip. Penis short and stout. Beneath the penis, an elongated plate with proximal end rounded. (Plate II, fig. 6.)

Trichodectes serraticus n.sp. Plate II, figs. 7–9.

Several males and females taken in company with the previous species from a Cape Hyrax (*Procavia capensis*), shot at Mtabamhlope, Estcourt District, Natal by Mr P. Barnes.

Female. Total length 1·25 mm., length of head 0·33 mm., length of prothorax 0·09 mm., length of metathorax 0·12 mm., length of abdomen 0·71 mm. Width of head 0·33 mm., width of prothorax 0·22 mm., width of metathorax 0·23 mm., width of abdomen 0·49 mm.

Head. Light yellowish-brown, as broad as long. Forehead rounded, with four hairs on each side and a long shallow median notch produced into a medium trabecula-like process in front of each antenna. Antennal bands dark, narrow at their base, broadening out into a deep serrated band of dark brown towards the centre of the forehead. Ocular projections pronounced extending well beyond the temples which are rounded. Occipital margin slightly convex. Temples rounded, with a narrow dark marginal band, and with three short pustulated hairs on each side. Occipital bands narrow, connected at their bases by a broad, dark brown band, and meeting the antennal bands in front of the trabecula-like processes. Antennae long and narrow, reaching just beyond the posterior margin of the head; third joint the longest, with three small hairs; second joint nearly as long as the first, and each bearing two small pustulated hairs. Eye pronounced. On the dorsal surface of the forehead, there are four small hairs on each side situated just within the antero-lateral margin. On the hind-head a small pustulated hair on each side close to the ocular projection, and a semicircular row of six small hairs near the posterior margin of the head.

Prothorax. More than twice as broad as long, with lateral bands of dark

brown; marginal band faint and interrupted in the middle. Posterior margin very slightly convex, becoming deeply curved towards the lateral margins, which are slightly rounded.

Metathorax. Slightly wider, and longer than the prothorax, the lateral margins curved and bordered with a narrow dark band, the posterior margin slightly convex.

Abdomen. Oval in shape, broadest at third segment, whitish in colour, with a small brown transverse band on the dorsal surface of segments 1–6; seventh segment with the transverse band involving the whole of the segment. On the dorsal surface, first segment bare, with a deep marginal band of dark brown; second segment with a median group of four hairs widely spaced, and one pair at each lateral margin; third segment with twenty pustulated hairs; fourth segment with a row of sixteen pustulated hairs; fifth segment with a row of fourteen pustulated hairs; sixth segment with a row of fourteen hairs and two short hairs at the angle of the postero-lateral margin; seventh segment with a semicircular row of twelve pustulated hairs; last segment bilobed at the apex, with a row of eight pustulated hairs, and two short hairs on each lobe.

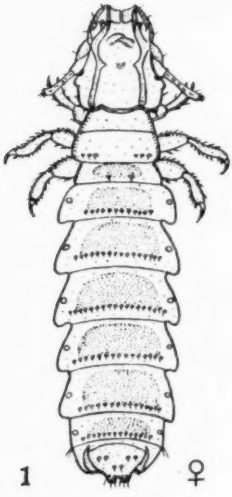
Male. Total length 1·16 mm., length of head 0·30 mm., length of prothorax 0·11 mm., length of metathorax 0·12 mm., length of abdomen 0·63 mm. Width of head 0·30 mm., width of prothorax 0·21 mm., width of metathorax 0·22 mm., width of abdomen 0·40 mm.

Head. The head generally resembles the female in outline, except that the antennal sinuses are much wider. Ocular projections extremely small. Antennae large and backward pointing, extending well beyond the occipital margin of the head, the first segment large and broad; second segment practically the same length as the first; the third segment the longest. On the dorsal surface of the head, a row of six small pustulated hairs close to the anterior margin, two small hairs situated in the centre of the head, mid-way between the bases of the antennae and the ocular projections, and a group of three to four hairs on the temples.

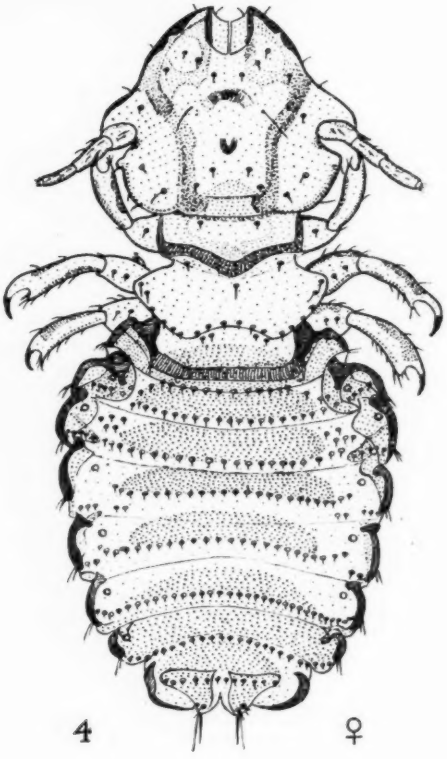
Prothorax. Produced sharply posteriorly, with a deep emargination at the posterior margin; lateral margins slightly rounded.

Abdomen. Oval, widest across the fourth segment. First segment entirely lacking the deep marginal broad band of the female; a brown transverse band on the dorsal surface of segments one to five; segments six to eight with an irregularly shaped and fused transverse band; last segment oval, with five to six short hairs along the posterior margin; first segment with a row of eight hairs; second segment with a row of fourteen hairs; third segment with a row of sixteen hairs; fourth segment with an unevenly spaced row of fourteen hairs; fifth and sixth segments with a row of fifteen to seventeen hairs; last segment with a closely set row of ten hairs.

Genitalia. Conspicuous, as shown in Plate II, fig. 9.

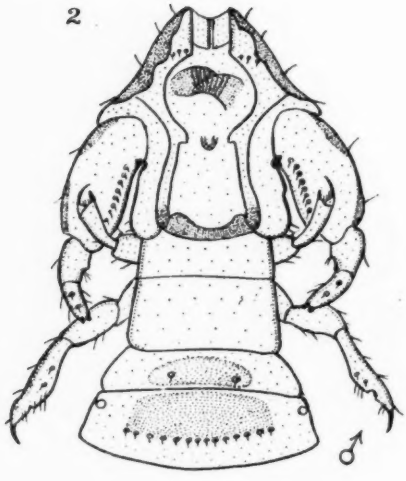


1 ♀

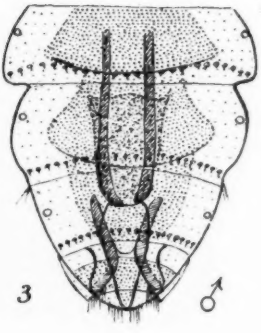


4 ♀

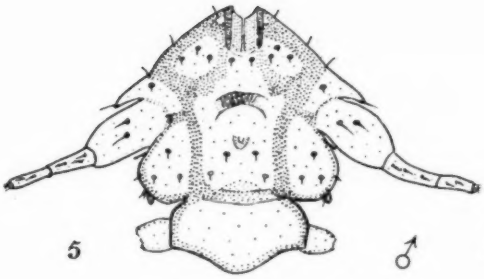
2



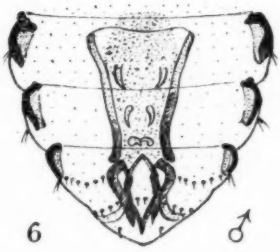
♂



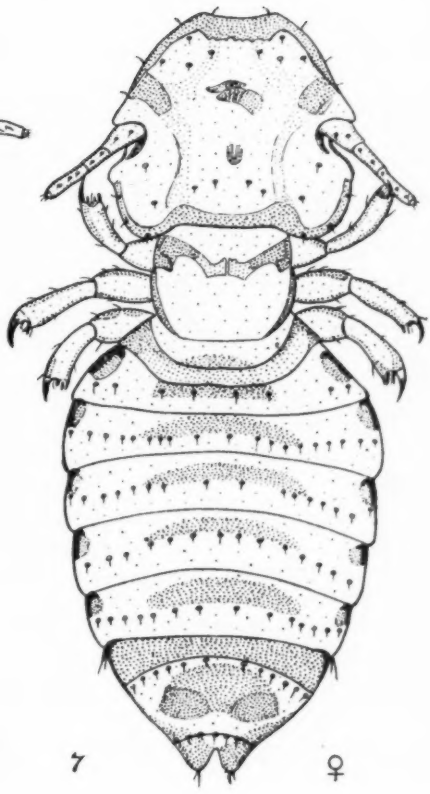
3 ♂



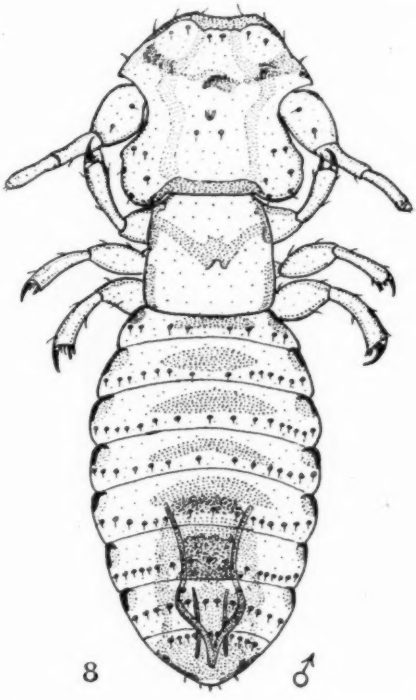
5 ♂



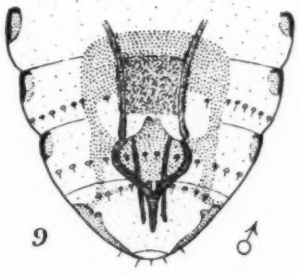
6 ♂



7 ♀



8 ♂



9 ♂

DESCRIPTION OF PLATE II.

Trichodectes bedfordi n.sp.

Fig. 1. Female.
Fig. 2. Head of male.
Fig. 3. Last abdominal segments and genitalia of male.

Trichodectes lindfieldi n.sp.

Fig. 4. Female.
Fig. 5. Head of male.
Fig. 6. Last abdominal segments and genitalia of male.

Trichodectes serraticus n.sp.

Fig. 7. Female.
Fig. 8. Male.
Fig. 9. Last abdominal segments and genitalia of male.

ON THE LARVA AND PUPA OF A PARASITIC PHORID FLY—*HYPOCERA INCRASSATA* MG.

By HUBERT M. MORRIS, M.Sc., F.E.S.

(*Entomological Dept., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden.*)

(Plate III and 4 Text-figures.)

CONTENTS.

	PAGE		PAGE
1. The Larva	70	5. Comparison with Larvae of other Phoridae	74
2. The Puparium	73	6. References to Literature . . .	74
3. The Pupa	73	7. Description of Plate . . .	74
4. Emergence of Adult from Puparium	73		

On Jan. 27th, 1920, among a number of nearly fully grown larvae of *Bibio marci* which had been kept in the laboratory about two weeks, a few individuals were observed to be unhealthy or dead. These latter were found to contain parasitic Dipterous larvae, which eventually proved to be those of *Hypocera incrassata* Mg. Certain of these larvae were observed to be leaving the bodies of other larvae of *Bibio marci* at the same time.

The larvae of *Hypocera incrassata* pupated in the soil immediately after leaving their hosts, and only a single parasite was observed in each of the latter.

The pupae were kept in soil in the laboratory, and the adults emerged between June 24th and July 1st.

The larva and pupa of *Hypocera incrassata* appear to be undescribed. It is noteworthy that *H. vitripennis* is recorded as having been reared from humble-bees' and wasps' nests (4), and *H. vectabilis* from dried specimens of Coleoptera (1).

The present species is of additional interest as being the first definite record of an insect parasitic on Bibionid larvae.

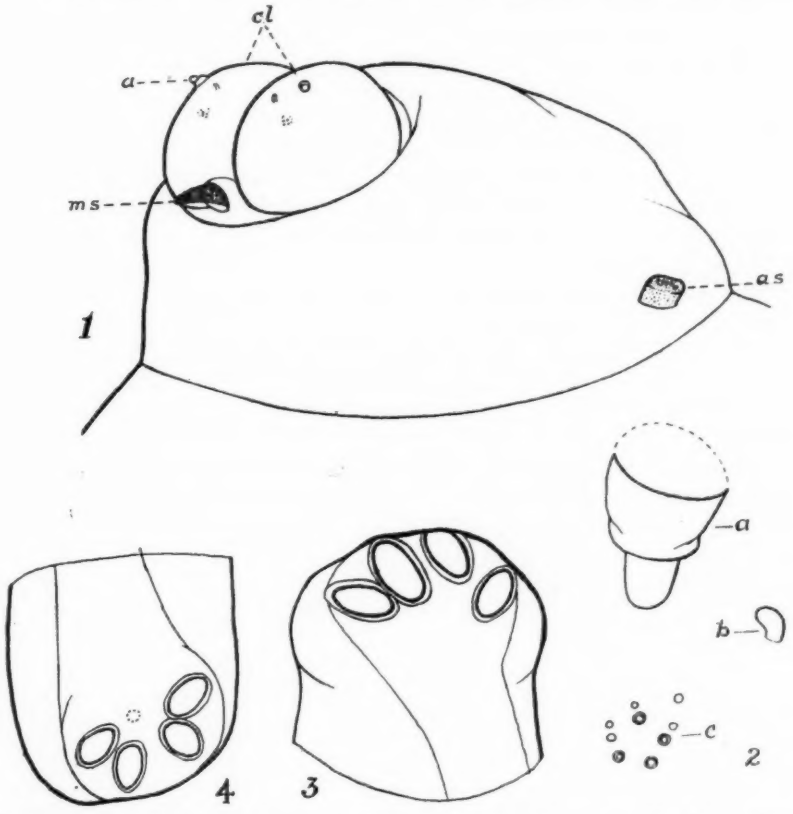
I am indebted to Dr D. Keilin for the identification of the adult flies, and for the information regarding previous records of the rearing of species of *Hypocera*. I am also much indebted to Dr A. D. Imms for advice during the preparation of this paper.

1. THE LARVA.

The larvae were not observed until they were leaving, or about to leave, the body of the host, and were then fully grown. At this stage they are about 8·0 mm. to 8·5 mm. in length and about 2·0 mm. in breath, and are of a yellowish-white colour.

External Form. The larva (Plate III, fig. 1) is composed of a small cephalic region, and eleven body segments, the segmentation being fairly distinct, but somewhat obscured by the presence of supplementary folds.

On the ventral surface of the cephalic region is a small opening, the mouth,



Text-fig. 1. Cephalic and prothoracic segments of larva of *Hypocera incrassata* Mg. Latero-ventral view. *a.*, antennal organ; *as.*, anterior spiracle; *cl.*, cephalic lobes; *ms.*, mandibular sclerite. ×32.

Text-fig. 2. Sensory structures on cephalic lobe. *a.*, antennal organ; *b.*, club-shaped projecting structure; *c.*, group of papillae. ×670.

Text-fig. 3. Anterior spiracle of larva of *Hypocera incrassata* Mg. ×670.

Text-fig. 4. Posterior spiracle of larva of *Hypocera incrassata* Mg. ×670.

from which projects the single mandibular sclerite (Text-fig. 1). Dorsal to the mouth are a pair of hemispherical lobes, bearing sensory structures. The most conspicuous of these structures is the antennal organ, which consists of two segments, the basal segment of which is cylindrical, and the distal segment dome- or bell-shaped (Text-fig. 2 *a*).

Close to the antennal organ, but rather ventral to it, is a minute slightly curved and somewhat club-shaped projecting organ; near the latter there is also a small group of minute papillae (Text-fig. 2 *b* and *c*).

The first segment of the body is small and rather conical, and near its posterior margin is a pair of projecting lateral spiracles which are brown in colour. Dorsally this segment bears a slight median transverse depression.

The remaining segments, except the last, are cylindrical, and increase in size to the sixth, after which they are approximately equal in size. The second and third segments are each divided dorsally into two parts by a median transverse sulcus. On each of the following segments, from the fourth to the ninth, there are three similar sulci. The second and third of the regions so formed in each segment are less clearly defined than the first and fourth, and it may be added that the third and fourth regions increase slightly in prominence on the posterior segments.

The tenth segment is divided, dorsally, into three regions, of which the third is the most conspicuous.

The terminal segment is in the form of a blunt cone, and is divided dorsally into three regions, of which the first is the largest and bears the pair of small posterior spiracles laterally. The terminal portion of this segment is rather flattened.

Ventrally, the first segment is undivided; the second segment is very faintly divided, and the third segment more distinctly divided into two regions. The fourth to tenth segments are divided into three regions, of which the first is very slightly the more prominent.

The terminal segment is similarly divided into three parts, and bears the conspicuous aperture of the anus on the foremost division. On each side of the anus is a rather prominent rounded fleshy process.

Buccopharyngeal Armature (Plate III, figs. 4 and 5). The buccopharyngeal armature is divided into three parts: (1) the pharyngeal or basal sclerite, (2) the intermediate sclerites, and (3) the mandibular sclerite.

(1) The pharyngeal sclerite is prolonged posteriorly (dorsally and ventrally) as a very delicate chitinous structure, the dorsal prolongation being much the longer. Its anterior end is strongly chitinised and bears on each side a hollow for the articulation of the intermediate sclerite.

(2) The intermediate sclerites are stout and strongly chitinised and are not fused together. They articulate with the hollows at the anterior end of the pharyngeal sclerite by means of a hook-like prolongation at their posterior end.

(3) The mandibular sclerite is a single very stout structure. It articulates with the intermediate sclerites by means of a pair of backwardly directed divergent arms at its posterior end. Ventrally, near the base, it bears several slight transverse ridges suggestive of vestigeal teeth.

Articulating with a slight projection at the anterior external angle of either intermediate sclerite is a delicate process, more strongly chitinised at its base,

and having the form shown in Plate III, fig. 6. At its distal extremity each process bears several projecting spines. These processes bear some resemblance to those described by Keilin (3) as "Baguettes orales" (oral rods) in carnivorous Anthomyid larvae.

Tracheal System. The tracheal system is amphipneustic, a pair of spiracles being situated on both the first and last segments of the body.

Both pairs of spiracles are very alike in size and structure and are brown, chitinised outgrowths from the body-wall: each spiracle communicates with the exterior by means of four oval apertures situated at its apex (Text-figs. 3 and 4).

2. THE PUPARIUM.

The puparium is brown, with the segments fairly clearly marked. It is about 5·0 mm. in length.

Dorsally there are several conspicuous constrictions. The prothoracic spiracular horns of the pupa emerge from the puparium through a pair of holes situated in a somewhat lateral position on its dorsal side, at the posterior end of the fourth body segment of the larva (Plate III, fig. 2).

These horns are about 0·23 mm. in length, and their distal half bears two rows of minute openings, about sixteen openings in each row. Both pairs of larval spiracles remain as conspicuous dark projections from the puparium, and the mandibular sclerite also projects at the anterior extremity.

3. THE PUPA.

The pupa, seen on removal from the puparium is white, with the appendages of the adult fly closely adpressed to the body. Its general characters can be seen on referring to Plate III, fig. 3, and scarcely need detailed description.

The head is of moderate size, and the antennae are large and are produced in a long slender process. The palpi are conspicuous and conical in shape. The labrum is short and flattened. The legs lie side by side, the tarsi of the posterior pair projecting slightly beyond the apex of the abdomen.

4. EMERGENCE OF ADULT FROM PUPARIUM.

When the adult fly emerges from the puparium, the latter is split in the following way. A circular cap, consisting of the skin of the cephalic region and thoracic segments of the larva, is split off by means of a fissure passing round the body between the third thoracic and first abdominal segments. A quadrangular plate is split off in addition, and it consists of the whole skin of the dorsal surface of the first three abdominal segments.

This plate may become completely detached, or may remain slightly adhering at its posterior end to the anterior margin of the fourth abdominal segment.

5. COMPARISON WITH LARVAE OF OTHER PHORIDAE.

The larva of *Hypocera incrassata* differs considerably from the larvae of *Phora Bergenstammi* Mik., *P. rufipes* Mg., and *P. ruficornis* Mg., as described by Keilin (2).

The buccopharyngeal armature is very different as may be seen by comparison with Keilin's figures. The numerous sensory structures on the cuticle of the latter larvae are not present in the case of *Hypocera incrassata*.

The absence of sensory structures may be an adaptation to a more completely parasitic existence, as may also be the simpler buccopharyngeal armature, with the fusion of the usual two mandibular sclerites into an unpaired organ.

The study of this larva lends support to the opinions of Brues, de Meijere and Keilin that the position of the Phoridae in the classification of the Diptera should be among the Cyclorrhapha.

REFERENCES.

(1) Brues, C. T. (1913). A New Species of Phoridae reared from dried Coleoptera. *Ann. Mus. Nation. Hung.* XI.

(2) Keilin, D. (1911). Recherches sur la morphologie larvaire des Diptères du genre *Phora*. *Bull. Sci. France et Belg.* 7me série, T. XLIV, i.

(3) Keilin, D. (1917). Recherches sur les Anthomyides à larves carnivores. *Parasitology*, IX, 3.

(4) Wood, J. H. (1906). On the British Species of *Phora* (Part I). *Ent. Mon. Mag.* XVII.

DESCRIPTION OF PLATE III.

Larval and Pupal Stages of *Hypocera incrassata* Mg.

Fig. 1. Fully grown larva. Dorsal view, *as.*, anterior spiracle; *ps.*, posterior spiracle. × 20.

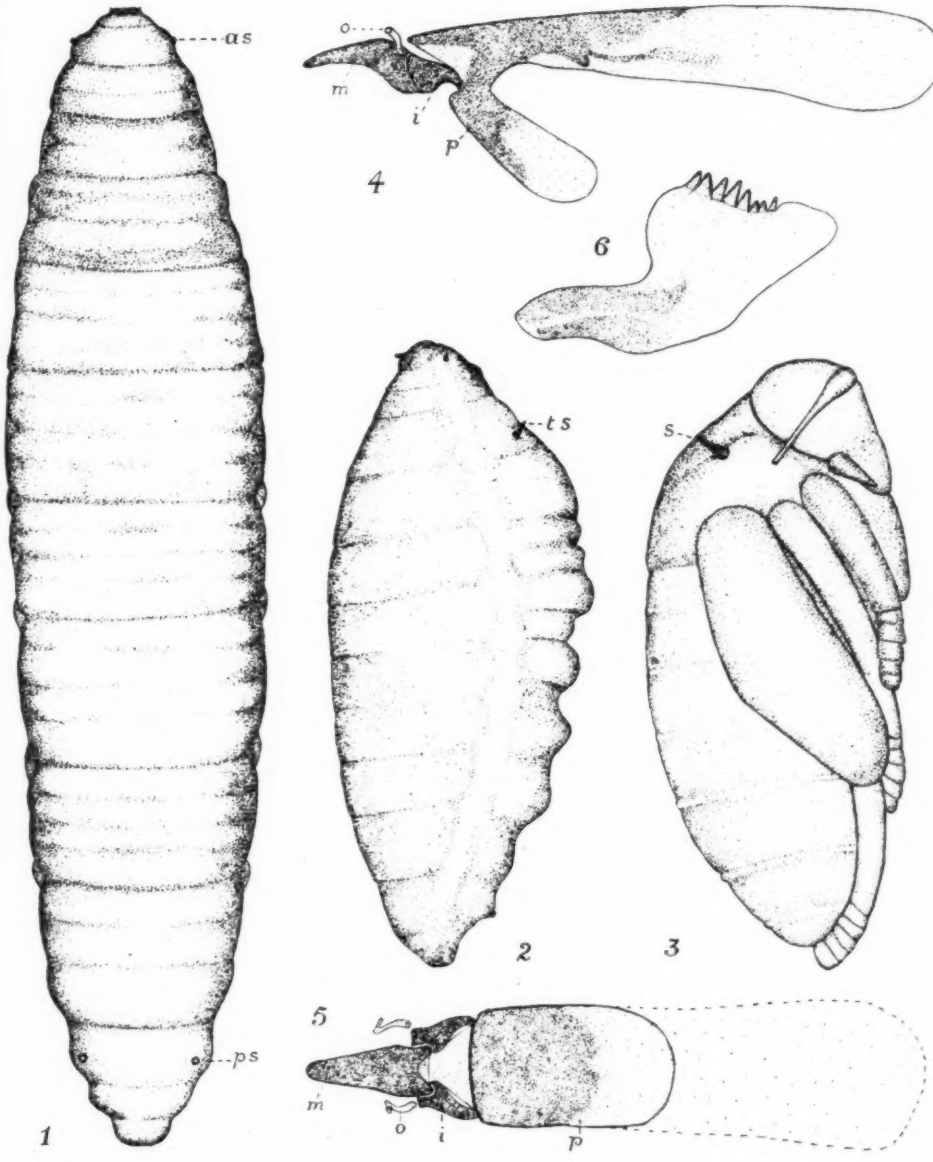
Fig. 2. Puparium. Lateral view. *ts.*, protruding spiracular horn of pupa. × 20.

Fig. 3. Pupa removed from puparium. Lateral view. *s.*, prothoracic spiracular horn. × 20.

Fig. 4. Buccopharyngeal armature of larva. Lateral view. *i.*, intermediate sclerite; *m.*, mandibular sclerite; *o.*, "baguette orale"; *p.*, pharyngeal sclerite. × 126.

Fig. 5. Buccopharyngeal armature of larva. Ventral view. Lettering as in previous figure. × 126.

Fig. 6. "Baguette orale" of larva × 730.



H. M. Morris del.

THE MALLOPHAGAN FAMILY *TRIMENOPONIDAE.*

By G. F. FERRIS, M.A.,
Stanford University, California.

(With 8 Text-figures.)

THREE species of two-clawed Mallophaga have heretofore been recorded from South American mammals. Concerning one of these species, *Menopon extraneum* Piaget, nothing is known aside from the information included in the original description and, judging from this and the accompanying figure, it appears not to differ from the usual type of bird-infesting members of this group. The other two species have each been made the type of a genus and these two genera have been considered by Harrison as representing a well-marked family, the *Trimenoponidae.*

Through the courtesy of the authorities of the United States National Museum and the Field Columbian Museum of Chicago, the present writer has been accorded the privilege of examining for parasites the mammal skins in the collections of these two institutions. Among the wealth of material thus discovered there have appeared three new species from South American mammals that are also referable to the family *Trimenoponidae.* In connection with the description of these three species, which necessitates the description of two new genera also, it has seemed desirable to review the family as a whole.

The types of the three new species are deposited in the collections of Stanford University. Paratypes of two of them, as indicated below, are deposited in the collections of the United States National Museum.

In the accompanying figures the left half represents the dorsal aspect, the right half the ventral aspect. Owing to the fact that the male in all the species here described is practically identical with the female in general form and appearance the female only has been figured in full.

Family **Trimenoponidae** Harrison.

1915. Harrison, *Parasitology*, VIII, 123, 124.
1916. Harrison, *Parasitology*, IX, 27, 31.

In proposing this family, Harrison (1915), in a key to the groups of the Amblycera based upon the respiratory system, has separated it on the basis of the presence of but five pairs of abdominal stigmata and the presence of a posterior commissure. He states further: "Of these Group A is undoubtedly of family rank, *Trimenopon* occupying a very isolated position. It shows a superficial resemblance to the Boopidae, but is without the accessory sac in

the ♂ genitalia and the special sensory organs of the first three abdominal segments which characterise that family. In addition it exhibits a fusion of prothorax and mesothorax, a condition not seen elsewhere in the Mallophaga. *Trimenopon* must rank as the type genus of a family *Trimenoponidae*. *Philandesia*, which I have not had an opportunity to examine, probably belongs here also."

While recognising the fact that this group is rather distinct from the other Menoponoid forms I am somewhat dubious as to its deserving family rank. However, before any very definite conclusions may be arrived at a thorough review of all the members of the Menoponoid group will be necessary. For the present I am accepting the family. I present the following statement of its characters.

Menoponoid Mallophaga with abdominal stigmata present upon but five abdominal segments, the third to seventh; without a slit in the lateral margin of the head; without pharyngeal glands; with the antennae four-segmented; without combs or brushes of setae on the ventral side of the posterior femora or any of the abdominal sternites; with the mesonotum distinct or sometimes entirely fused with the pronotum, the pronotum usually strongly winged.

As has been many times pointed out one of the most interesting problems in connection with the study of these ectoparasites is that of their distribution. This is, at least in part, the problem of the genetic relationships of their hosts. Just how far the two problems are concurrent is the most fascinating aspect of it all. In the case of the South American two-clawed species infesting mammals it is evident that the two problems diverge rather early, at least if we may form any conclusions from the rather scanty amount of information that is available.

The majority of the two-clawed Mallophaga from mammals have been taken from marsupials in Australia and for these Harrison has named a distinct family the Boopidae. Two of the species herein dealt with are from marsupials, but apparently they find their nearest relatives not in the Australian marsupial-infesting species but in other species from South American rodents. The one consolation for those of us who like to see our theories work as they should is that these two species are apparently referable to the same genus. Of the other three species, one is from members of the rodent family *Lagostomidae*, one from the family *Octodontidae* and one from the family *Caviidae*. There is at least a suggestion that here the problem of the distribution of the parasites is in large part geographical.

A similar situation appears to exist in the case of the Mallophagan family, *Gyropidae*, the members of which occur upon mammals that appear to have little more in common than the circumstance that all are South American. True, one species of this group has been described from a European rodent, but I am inclined to regard this record with grave suspicion. A rather extensive collection of Gyropids is available to me, and I hope in a later paper to consider this group at length.

Genus **Trimenopon** Cummings.

1913. Cummings, *Bull. Ent. Res.* IV, 39.
1915. Harrison, *Parasitology*, VIII, 123, 124.
1916. Harrison, *Parasitology*, IX, 31.

The original description of this genus requires some modification. I rewrite it as follows:

Mallophaga of the family *Trimenoponidae*; with the lateral margins of the head not emarginate or notched; without spines on the ventral side of the head; with the clypeal region delimited dorsally by a distinct suture; with the antennal fossae partially covered beneath by a flap; with distinct pulvilli on the first tarsal segment; with the genitalia of the male of a very complex type.

Type of the genus, *Menopon jenningsi* Kellogg and Paine. This is the only included species.

Trimenopon jenningsi (Kellogg and Paine).

Figs. 1, 2 A, 3 A, 4 B.

1910. *Menopon jenningsi* Kellogg and Paine, *Ent. News*, XXI, 461; Fig.
1912. *Menopon jenningsi* K. and P., Paine, *Ent. News*, XXIII, 442.
1913. *Trimenopon echinoderma* Cummings, *Bull. Ent. Res.* IV, 40; Fig. 4.
1916. *Trimenopon jenningsi* (K. and P.), Harrison, *Parasitology*, IX, 31.

PREVIOUS RECORDS. From *Cavia cobaya*, Panama Canal Zone (Kellogg and Paine); *Cavia cutleri*, Peru (Paine); *Cavia aperea*, Paraguay (Cummings).

SPECIMENS EXAMINED. The types of Kellogg and Paine.

Notes. The original descriptions of this species, especially that of Cummings, are in general quite detailed and I shall content myself here principally with somewhat more detailed figures for comparison with the other species of the family.

I think there can be no question that *T. echinoderma* Cummings is a synonym of *T. jenningsi* (K. and P.) as Harrison has indicated in his Catalogue of the Mallophaga (1916). Cummings states that the antennae of his species are five-segmented, while in *jenningsi* they are certainly but four-segmented, but as the two species agree in all other respects and as all the other species of the family have the antennae but four-segmented it seems quite certain that Cummings was in error.

Genus **Philandesia** Kellogg and Nakayama.

1914. Kellogg and Nakayama, *Ent. News*, XXV, 198.
1916. Harrison, *Parasitology*, IX, 31.

Mallophaga of the family *Trimenoponidae*; with the lateral margin of the head deeply sinuate-emarginate; without spines on the ventral side of the head; with the clypeal region delimited dorsally by a suture; with the antennal fossae covered beneath by a flap; with the labium provided with a pair of forward-pointing processes; with distinct pulvilli on the first tarsal segment; with the genitalia of the male of a very complex type.

TYPE OF THE GENUS. *Philandesia townsendi* Kellogg and Nakayama. This is the only included species.

Philandesia townsendi Kellogg and Nakayama.

Figs. 2 B, 3 B, 4 A, 5.

1914. Kellogg and Nakayama, *Ent. News*, XXV, 199–200; Pl. 8.
1916. Harrison, *Parasitology*, IX, 31.

PREVIOUS RECORDS. From *Lagidium peruanum*, Peru.

SPECIMENS EXAMINED. One female and two males taken from a skin of *Viscacia inca* Junin, Peru (Field Columbian Museum). The types of the species are in the Stanford Collection but appear to have been mislaid and were not

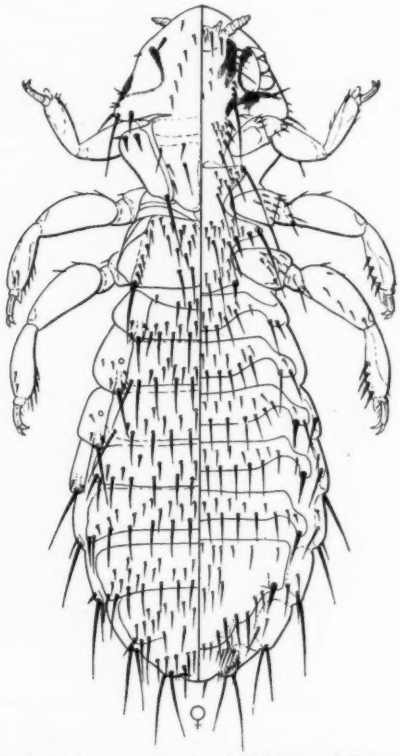


Fig. 1. *Trimenopon jenningsi* (Kellogg and Paine).

examined in connection with the preparation of this paper. The hosts are members of the rodent family *Lagostomidae*.

Notes. There is little to add to the original description but I am presenting figures for comparison with the other members of the family. The original figure shows the mesonotum as entirely suppressed but this is in error, for the mesonotum, although small, is nevertheless present. The genitalia of the male (Fig. 4 A) are extremely complicated, so much so that with the scanty amount

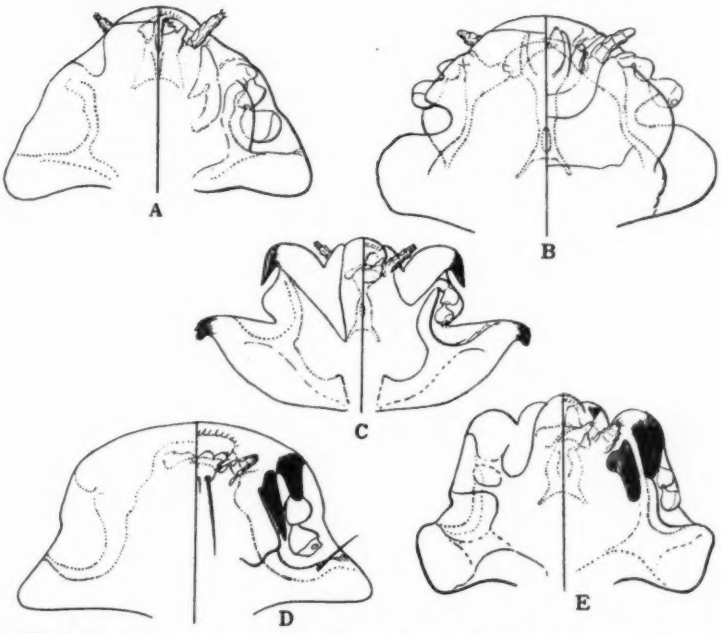


Fig. 2. Heads of: A, *Trimenopon jenningsi* (K. and P.); B, *Philandesia townsendi* (K. and N.); C, *Harrisonia uncinata* n.sp.; D, *Cummingsia peramydis* n.sp.; E, *Cummingsia maculata* n.sp.

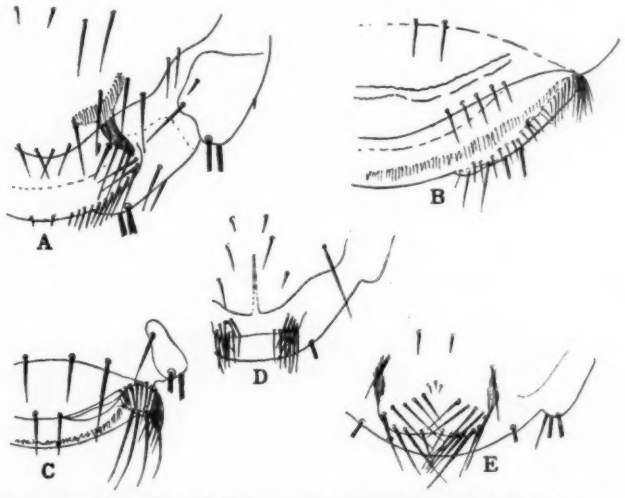


Fig. 3. Genital region of female of: A, *Trimenopon jenningsi* (K. and P.); B, *Philandesia townsendi* (K. and N.); C, *Harrisonia uncinata* n.sp.; D, *Cummingsia maculata* n.sp.; E, *Cummingsia peramydis* n.sp.

of material available I am unable to do more than give a general sketch of their appearance.

Genus **Harrisonia** nov.

Mallophaga of the family *Trimenoponidae*; with the posterior portion of the head strongly produced laterally, the process ending in a heavily chitinised, flattened hook and with the anterior lateral angles of the head produced into a strong, downward and backward pointing, heavily chitinised hook; with the clypeal region not delimited dorsally by a suture; with the antennal fossae

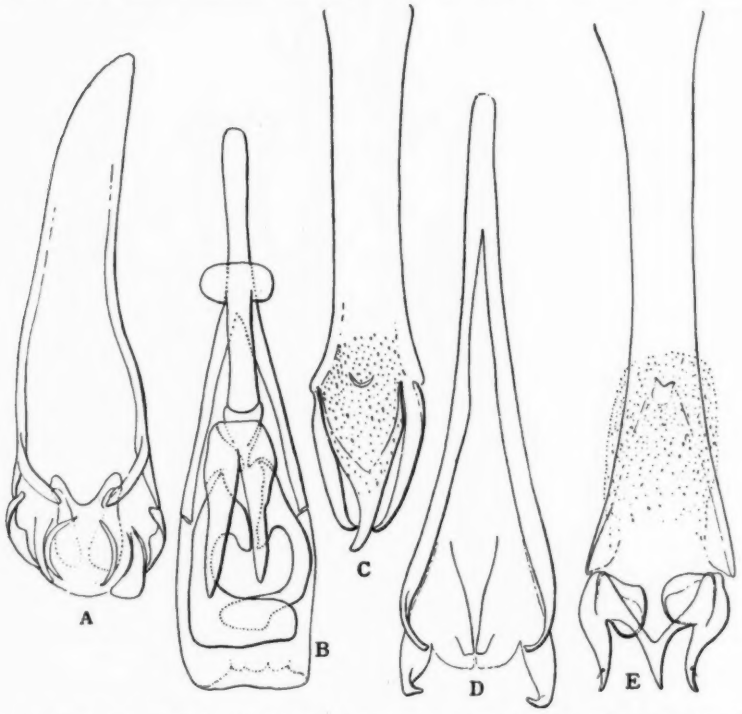


Fig. 4. Genitalia of males of: A, *Philandesia townsendi* (K. and N.); B, *Trimenopon jenningsi* (K. and P.); C, *Cummingsia peramydis* n.sp.; D, *Harrisonia uncinata* n.sp.; E, *Cummingsia maculata* n.sp.

not covered beneath by a flap; with the mesothorax fused with the prothorax; with small pulvilli on the first segment of the tarsi; with the genitalia of the male of a very simple type.

Type of the Genus. *Harrisonia uncinata* n.sp. This is the only included species.

Notes. The extraordinary form of the head, together with the other characters enumerated, seems adequately to justify the erection of a new genus. The single included species is one of the most remarkable forms yet described

among the Mallophaga but it appears to be quite definitely a member of the *Trimenopon* group.

I am naming this genus in honour of Mr Lancelot Harrison as a token of appreciation of the stimulating quality of his work on the Mallophaga.

Harrisonia uncinata n.sp.

Figs. 2 c, 3 c, 4 d, 6.

Specimens Examined. A single female, the holotype, from *Hoplomys gymnurus*; one male, the allotype, from *Nelomys mirae*; and one male paratype

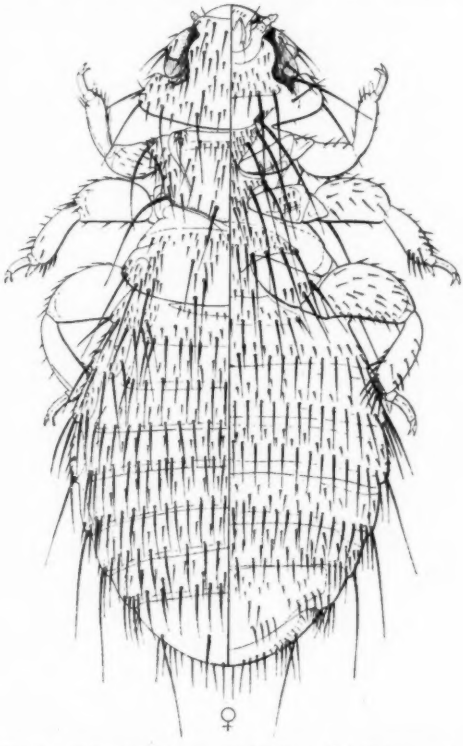


Fig. 5. *Philandesia townsendi* (Kellogg and Nakayama).

from *Proechimys semispinosus*; all from San Javier, North Ecuador. The specimens are from skins in the United States National Museum and a paratype of the new species will be deposited with that institution. All the hosts are members of the rodent family *Octodontidae*.

Female (Fig. 6). Length 1·1 mm. General form rather stout. *Head* (Fig. 2 c) as described for the genus. The clypeal region is very small, is semicircular in form and is bounded on each side both dorsally and ventrally by

a heavily chitinised area from which rises the strong, downward curved hook at each anterior angle of the head. Slightly lateral of the clypeal region the anterior margin is deeply notched on each side. The flap covering the antennal fossa is strongly chitinised and is separated by a deep notch from the laterally produced posterior portion of the head. On the ventral side the wall of the antennal fossa is strongly chitinised, this chitinisation extending in a curve to the posterior margin of the head near the median line. The maxillary palpi are rather slender and the mouth-parts present no special characters.

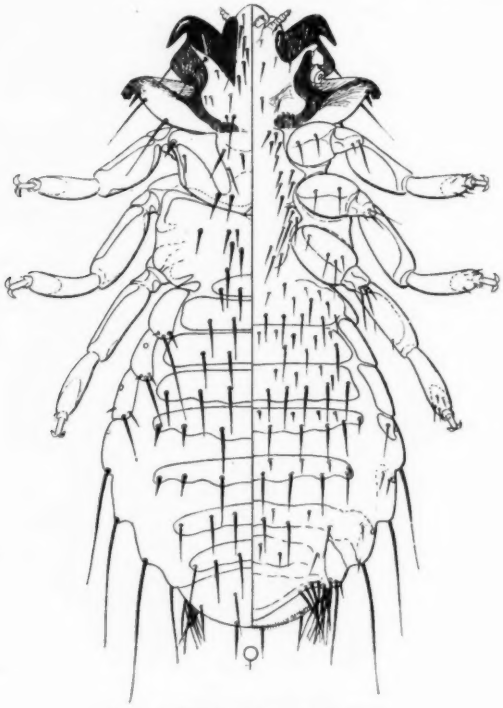


Fig. 6. *Harrisonia uncinata* n.sp.

Prothorax and mesothorax closely united, the mesonotum reduced merely to a chitinised, transverse bar that is concealed beneath the posterior margin of the mesonotum. The pronotum bears a pair of broad, heavily chitinised, diagonal bars and the lateral margins of the mesonotum are heavily chitinised. Dorsally both segments bear several quite stout setae and ventrally there is a longitudinal series of smaller setae at the base of the coxae.

Abdomen with the pleural plates strongly developed on the third to fifth segments, each bearing a single long and several small setae. The lateral margins of the sixth to ninth segments each bear a single long seta. Tergal

and sternal plates strongly developed on all the segments except on the first sternite. The tergal plates bear a single transverse row of four or six setae while the sternal plates for the most part bear one row of large setae and an irregular row of much smaller setae.

The genital region (Fig. 3 c) bears a cluster of setae near each lateral margin.

Male. Length 1 mm. In general form and structure closely resembling the female. The genitalia (Fig. 4 d) are very simple. The basal plate is composed of a pair of long, slender rods, united at the anterior extremity in the form of an inverted V. At the tip of each of these rods is a short piece terminating in a hook, these probably representing the parameres, and between the tips of the rods are a pair of flattened, pointed pieces of doubtful homology.

Genus **Cummingsia** nov.

Mallophaga of the family *Trimenoponidae*; with the lateral margin of the head at the most but slightly notched; with two pairs of strong, flattened, backward-pointing spines on the ventral side of the head, these arising from just before the bases of the antennae; with the clypeal region not delimited dorsally by a transverse suture; with the antennal fossae not covered beneath by a flap; with the mesonotum quite distinct; without pulvilli on the first segment of the tarsi; with the genitalia of the males of a simple type.

Type of the Genus. *Cummingsia maculata* n.sp. One other species, *C. peramydis* n.sp., is included.

Notes. It is with some hesitation that I refer the two species above named to the same genus, for in the structure of the head there is a rather notable difference. I would especially call attention to the apparent absence of the maxillary lobes in *C. peramydis*. However, they are not so different that their association in the same genus is entirely incongruous and in some respects they are very similar.

I am naming this genus in honour of the late Bruce Cummings, by whom *Trimenopon*, the type-genus of this family was established.

Cummingsia maculata n.sp.

Figs. 2 e, 3 d, 4 e, 7.

Specimens Examined. One female, the holotype, and three males from *Caenolestes* sp., Cedrobamba Ruins, Peru. The specimens are from a skin in the United States National Museum and a paratype of the species will be deposited in the collections of that institution. The host is a marsupial.

Female (Fig. 7). Length 1·2 mm. *Head* somewhat wider than long, nearly truncate anteriorly and with a slight notch in the lateral margin. Clypeal region very small, bounded dorsally by an elongate, heavily chitinised area on each side that extends nearly to the middle of the head. Beyond this area is a smaller area at the anterior lateral angle which extends to the ventral side and from which rises the pair of flattened spines. The wall of the antennal fossa is heavily chitinised. The maxillary palpi are very short and stout.

Thorax with the mesonotum distinctly developed. The pronotum and mesonotum each bear a few small setae and one or two pairs of long setae along the posterior margin. The sternites of the thorax bear numerous scattered setae.

Abdomen with the pleural plates well developed on the second to fourth segments, very weakly so on the remainder, each plate with several small setae and with a single long seta at the dorsal posterior angle. Tergal and sternal plates strongly developed, for the most part bearing a single transverse

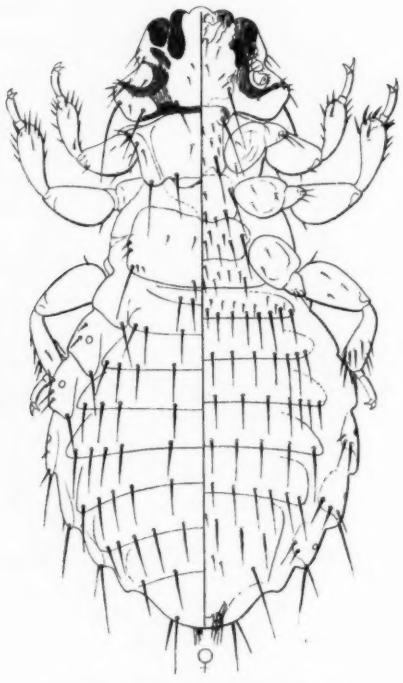


Fig. 7. *Cummingsia maculata* **n.sp.**

row of ten or more slender setae. Genital region (Fig. 3 D) with two submedian clusters of small setae.

Male. Length 1·1 mm. In general closely resembling the female. *Genitalia* (Fig. 4 E) with the basal plate very long and moderately broad, not divided. At the apex of the basal plate are the relatively small parameres, these curved, tapering and with an expanded basal portion. Between the parameres lies the quite large Y-shaped pseudopenis. The apical third of the basal plate is overlain by the vesicula penis, the walls of which are studded with minute teeth.

Cummingsia peramydis n.sp.

Figs. 2 D, 3 E, 4 C, 8.

SPECIMENS EXAMINED. Holotype, a female, four female paratypes and one male, the allotype, from *Peramys domesticus*, Quixada, Brazil, from skins in the Field Columbian Museum. The host is a marsupial.

Female (Fig. 8). Length 1·4 mm. *Head* (Fig. 2 D) somewhat broader than long, quite smoothly rounded anteriorly, with but the faintest indication of a notch in the lateral margin. The antennal fossae are quite deep and the

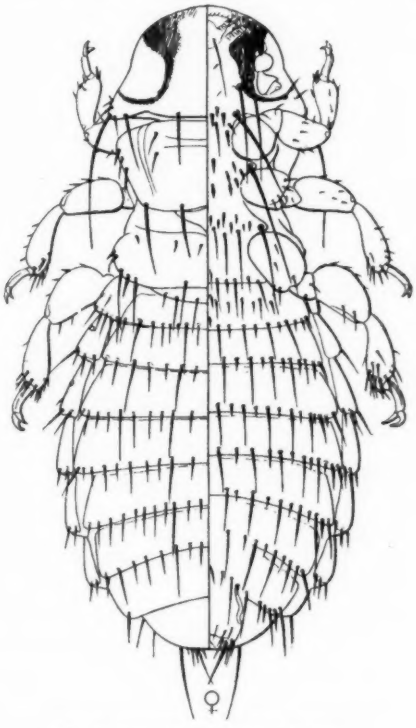


Fig. 8. *Cummingsia peramydis* n.sp.

wall is heavily chitinised, this chitinisation broadening anteriorly and extending to the anterior margin of the head. From it arises the strong ventral spines. The maxillary palpi are quite short and the maxillary lobes are apparently lacking.

Thorax with the mesonotum clearly present, the pronotum and metanotum bearing a few small setae and with two or three pairs of long setae along the posterior margin. The sternites of the thorax bear numerous short setae and near the base of each coxa is a single very long seta.

Abdomen with the pleural plates well developed on the second to seventh segments, each with a few small setae. Tergal and sternal plates strongly developed each bearing a transverse row of as many as twenty-four setae of variable lengths. The genital region (Fig. 3 E) bears numerous small setae.

Male. In general form and characters closely resembling the female. Length 1·2 mm. *Genitalia* (Fig. 4 C) with the basal plate quite long and moderately broad; parameres about a third as long as the basal plate, slender and tapering; pseudopenis large Y-shaped, attached to the vesicula penis, the walls of which are studded with small teeth.

ON *ASCARIS VITULORUM* GOEZE.

By C. L. BOULENGER, M.A., D.Sc.

(*From the Research Laboratory in Agricultural Zoology, University of Birmingham.*)

(With 3 Text-figures)

Until the appearance of Neumann's paper "Sur l'Ascaride des Bêtes Bovines" (1883), *Ascaris vitulorum* was not generally accepted as a valid species, the form from cattle being referred by different authorities either to *Ascaris lumbricoides* or *A. megalocephala*. Neumann's study of this worm showed, however, that the species differs in many important anatomical characters from the common Ascarids of the pig and the horse and since the publication of his memoir the specific identity of *A. vitulorum* has not been disputed.

My attention was called to this parasite in India last year, the material used for class purposes in the Punjab University including specimens of an *Ascaris* from the Indian domesticated buffalo (*Bos bubalis*). The general macroscopic anatomy of these worms, as seen dissected by students in the laboratory, seemed to agree very well with that described by Neumann, and at the time I had no doubt that I was dealing with the same species as that found in cattle in Europe.

Since my return to Birmingham I have subjected the material to closer microscopic study which showed that the Indian specimens differ in several characters, including some of considerable systematic importance, from the *A. vitulorum* as described by Neumann.

The specific diagnosis of *A. vitulorum*, as now generally accepted, is the following given by Ransom (1911) in his monograph on the Nematodes parasitic in the alimentary tract of Ruminants, and based no doubt largely on Neumann's account:

"Specific diagnosis.—*Ascaris*: Lips without papillae, narrowed anteriorly. Tail terminated by a mucronate, conical tip. Esophagus followed by a rudimentary ventricle.

Male 15 to 25 cm. long by 3 mm. in maximum thickness. Ventral surface of tail supplied with two irregular rows of 10 to 15 papillae each, all preanal.

Female 22 to 30 cm. long by 5 mm. in thickness. Vulva toward the anterior sixth of the body. Eggs 75 to 80 μ in length.

Hosts.—Cattle (*Bos taurus*); zebu (*Bos indicus*)."

The specimens from the Punjab fail to agree in two of the most important of these specific characters, namely the absence of cephalic papillae on the lips and postanal papillae on the male tail, the worms studied by me possessing distinct papillae on the lips in much the same position as in *A. lumbricoides*, the male individuals also bearing genital papillae behind the cloaca.

These, together with other less important points of difference[1], led me to believe that the worms from the Indian buffalo would prove specifically distinct from *A. vitulorum* from *Bos taurus*; I was, however, fortunately able to compare the Punjab material with some Ascarids from ordinary cattle collected by Mr H. E. Hornby in Northern Rhodesia, these proved to agree in all essential respects with the Indian form. I have not been able to obtain any Ascarids from cattle in England, further study will therefore be necessary to settle the questions as to whether the European form is identical with that from Indian and African sources, and whether the discrepancies are due to errors of observation on the part of Neumann or not.

The following account of *A. vitulorum* is based solely on the material from the Punjab and from Northern Rhodesia.

Ascaris vitulorum Goeze, 1782.

Ascaris vituli Gmelin, 1790 (in part).

Length, male, 17·5 to 21 cm.; female, 21 to 27 cm. Thickness, male, 4 to 5 mm.; female, 6 mm. Body colourless in spirit material, tapering at both extremities. Body-wall thin and somewhat translucent.

Cuticle with transverse striations about 0·05 mm. apart.

Head small, 0·7 to 0·95 mm. broad, there are three simple lips, without interlabia. The shape of the lips is as described by Neumann, each consisting of a broad basal region and a much narrower distal region, the latter with a slightly emarginate anterior border.

Dorsal lip 0·45 to 0·6 mm. broad, 0·32 to 0·47 mm. long; bearing two nearly circular, flattened papillae on the basal portion (Text-fig. 1). Ventral lips slightly narrower than the dorsal lip, each bearing a single papilla. The pulp of each lip is divided anteriorly into two lobes. Dentigerous ridges well developed, with strong teeth, 0·06 to 0·075 mm. apart.

Oesophagus considerably shorter than in allied species[2], 3 to 4·5 mm. in length, divided into two regions, the anterior muscular and club-shaped with a maximum thickness of 0·8 to 0·9 mm., the posterior region in the nature of a 'ventriculus,' 0·45 to 0·6 mm. long and 0·5 to 0·8 mm. broad. The walls of the ventricular region are largely granular in structure.

Male. Posterior extremity slightly curved ventrally. Caudal region with ventral surface distinctly flattened and terminating in a small mucronate

[1] *e.g.* the more forward position of the vulva in the female.

[2] In *A. lumbricoides* from the pig the oesophagus has a length of about 9 mm.

appendix. Cuticle of tail somewhat expanded, forming narrow *alae* in the region of the terminal appendix (Text-fig. 2).

Cloaca 0·45 mm. from the posterior extremity of the body.

Preanal papillae in two parallel rows, each consisting of about 13. Behind the cloaca is a pair of larger flattened postanal papillae, the pulps of which

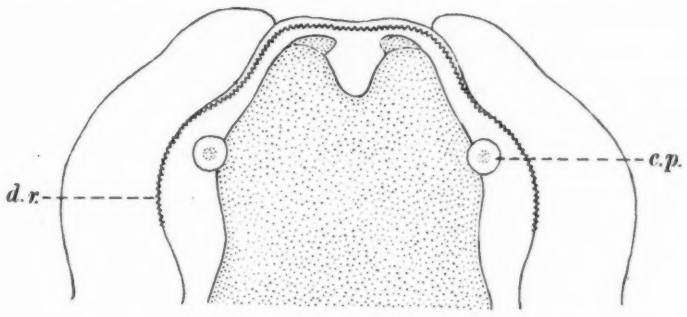


Fig. 1. *Ascaris vitulorum*. Head showing the dorsal lip with papillae. ×100.

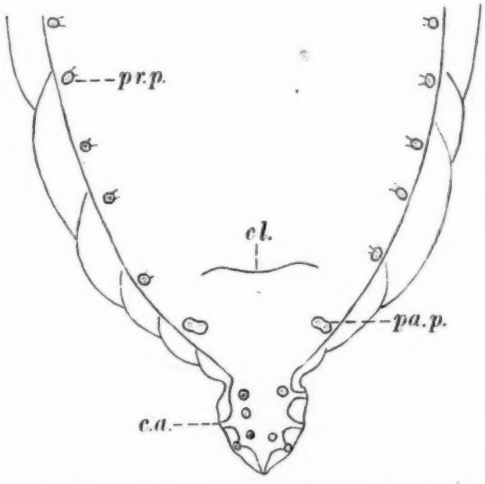


Fig. 2. *Ascaris vitulorum*. Posterior extremity of male, showing caudal appendix and preanal and postanal papillae. ×65. *c.a.* caudal appendix of male; *c.p.* cephalic papilla on dorsal lip; *cl.* cloaca of male; *d.r.* dentigerous ridge of lip; *pa.p.* postanal papilla; *pr.p.* preanal papilla.

have double terminations. The posterior appendix bears about five pairs of small papillae, somewhat irregularly arranged.

Spicules equal, about 0·95 mm. in length. The greatest thickness is about 0·04 mm. anteriorly, each spicule tapering gradually backwards and terminating bluntly.

Female, Tail short, the distance between the anus and the posterior extremity varies considerably in different specimens, from 0·6 to 1·1 mm. (Text-fig. 3).

Vulva situated anteriorly, 25–30 mm. from the cephalic extremity and dividing the total length of the body in the proportion 1 : 8. Internal female organs as described by Neumann; the uteri are fused posteriorly, forming a common tube continuous with the vagina, the latter has a length of about 10 mm., the total length of the unpaired genital duct measuring 30 mm.

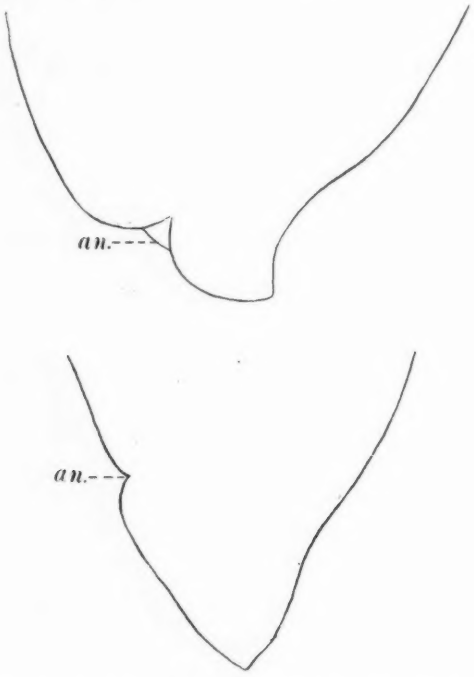


Fig. 3. *Ascaris vitulorum.* Posterior extremity of female, showing variation in length of caudal region, *an.* anus. ×35.

Paired uteri short, about 70 mm. in length, running backwards, parallel with one another; each oviduct bears a conspicuous swelling or ampulla close to its junction with the uterus.

Eggs 0·08–0·095 mm. long × 0·07–0·075 mm. wide, less coarsely mamillated than those of *A. lumbricoides*.

The character of the oesophagus in *A. vitulorum* is of considerable interest from the systematic point of view; recent authorities, *e.g.* Railliet and Henry (1912) and Baylis (1920), have attached great importance to the structure

of the alimentary canal in the classification of the family Ascaridae, the latter having proposed to unite in the sub-family Anisakinae all genera in which the oesophagus is divided into an anterior muscular portion and a posterior ventriculus of different histological structure.

There can be no doubt that, apart from the structure of the oesophagus, *A. vitulorum* is most closely allied to *A. lumbricoides* and *A. megalocephala* and must be retained in the genus *Ascaris* s. str.

The species described above is evidently a common parasite in both the localities from which my material was obtained; when sending the specimens from Northern Rhodesia Mr Hornby supplied the following interesting note on the occurrence of the worms in that district:

"These parasites are extraordinarily common and, when present in large numbers, cause scouring, wasting and death of the infested calves. Sometimes the small intestine bulges along its whole length owing to the number of worms present. Only sucking calves are affected. Growth after ingestion must be very rapid, as I have found hundreds of worms, from 1 to 7 inches long, in a calf only two weeks' old, and adult worms predominated in a six weeks' old animal."

I can obtain no definite information as to the time required by *A. vitulorum* to reach maturity after the ova have been ingested, in allied species, however, development is known to be rather slow, the experiments of Epstein (1892) on human subjects and of Ransom and Foster (1920) on pigs have shown that for *A. lumbricoides* a period of about two and a half months is required for full development from the egg in these hosts.

Mr Hornby's observations suggest either that the development of *A. vitulorum* in calves is much more rapid than that of *A. lumbricoides*, or that prenatal infection must take place. The possibility of prenatal infection cannot be excluded in view of the recent development of our knowledge of the migrations of young Ascarid larvae within their hosts.

Neveu-Lemaire (1912) has reported two cases of prenatal infestation in lambs with the lung-worm, *Dictyocaulus filaria*, other indisputable records of such infections with other parasites are to be found in the literature; Cort (1921) has recently published an interesting summary of the known cases.

REFERENCES.

BAYLIS, H. A. (1920). On the Classification of the Ascaridae. I. The Systematic Value of certain Characters of the Alimentary Canal. *Parasitology*, XII, 253–264.

CORT, W. W. (1921). Prenatal Infestation with parasitic Worms. *Journ. Amer. Med. Ass.* LXXVI, 170.

EPSTEIN, A. (1892). Ueber die Uebertragung des menschlichen Spulwurms (*Ascaris lumbricoides*). *Verh. d. Versamml. d. Gesellsch. f. Kinderh. deutsch. Naturf. u. Aerzte* (Wiesb.), V, 1–16.

NEUMANN, G. (1883). Sur l'Ascaride des Bêtes Bovines. *Rev. vétér.* (Toulouse), Août, 1–20.

NEVEU-LEMAIRE (1912). Strongylose bronchique congénitale du Mouton. *C. r. Acad. d. Sc.* CLIV, 1211.

RAILLIET, A. and HENRY, A. (1912). Quelques Nématodes parasites des Reptiles. *Bull. soc. Path. exot.* (Paris), v, 251.

RANSOM, B. H. (1911). The Nematodes parasitic in the Alimentary Tract of Cattle, Sheep, and other Ruminants. *U. S. Dept. Agr., Bur. Animal Ind.*, Bull. 127, 25.

RANSOM, B. H. and FOSTER, W. D. (1920). Observations on the Life History of *Ascaris lumbricoides*. *U. S. Dept. Agr.*, Bull. 817.

NOTES BEARING ON VAN BENEDEN, LEUCKART AND SONSINO WHOSE PORTRAITS APPEAR IN *PARASITOLOGY*, XIV, No. 1.

PORTRAIT-PLATES XII—XIV.

(Continuing the series begun in Vol. XIII.)

BY GEORGE H. F. NUTTALL, F.R.S.

(*From the Molteno Institute for Research in Parasitology, University of Cambridge.*)

Pierre Joseph van Beneden

1809–1894.

(Portrait-plate XII.)

PIERRE JOSEPH VAN BENEDEN was born 19 December, 1809, at Malines, Belgium, and died 8 January, 1894, at Louvain. He graduated in medicine (1831) and became Curator of the Natural History Museum, Louvain, where he became Professor of Zoology and Comparative Anatomy in 1836. Besides doing zoological work of high value which he pursued actively to the end of his life, he established at his own expense in 1843, a marine aquarium, one of the first of its kind. In parasitology he attained great distinction through his investigations upon the biology of parasitic worms and their relation to their hosts, his work *Mémoire sur les vers intestinaux* (viii + 376 pp. 28 pls. 4°), published in 1858, bringing him the "grand prix des Sciences physiques" of the Institut de France. In 1875 he published his results in popular form under the title *Les commensaux et les parasites dans le règne animal*, as one of the International Science Series, this appearing both in English and German translations. His publications number over 200 and he was joint author with Paul Gervais of a general work on medical zoology in two volumes (1859).

He was the recipient of many distinctions and much esteemed for his high character. He was elected Foreign Corresponding Member of the Royal Society in 1875 and President of the Royal Belgian Academy in 1881. He received the Hon. LL.D. Edinburgh in 1884 and was made Grand Officer of the Order of Leopold in 1886. He left a large family of daughters and one son,

Edward (1846–1910), who became Professor of Zoology at Liège in 1870 and likewise published contributions to parasitology.

For Biography see Obituary Notice in *Proc. Roy. Soc.* London, 1895, LVII, p. xx. A portrait appeared in *Arch. de Biol. Gand*, v. 16. A full Bibliography will be found in Stiles and Hassall (1902) *Index Catal. of Med. and Veter. Zool.* pp. 85–92; the papers relate to Cestoda, Trematoda, Nematoda, Hirudinea, parasitic Acari and Crustacea, Linguatula, etc. Our portrait is reproduced from a photograph obtained through the courtesy of Prof. J. Bordet of Brussels in 1920.

Rudolph Leuckart

1822–1898.

(Portrait-plate XIII.)

KARL GEORG FRIEDRICH RUDOLPH LEUCKART was born 7 October, 1822, at Helmstedt, Brunswick, and died 6 February, 1898, at Leipzig. In 1847 he became Privat Docent at Göttingen, in 1850–69 he was Professor of Zoology at Giessen and in 1870–98 he held the like chair at Leipzig. He distinguished himself especially as a helminthologist, being attracted to the subject through the work on parasitic worms carried out by his uncle, Prof. F. S. Leuckart (1794–1843).

His first helminthological work, on Cestodes, appeared in 1848. He wrote on Linguatulidae (Pentastoma, 1857–60), Pupipara, the nematoid worms *Attractonema* and *Sphaerularia*, on *Trichina spiralis* (discovered by Sir James Paget when a student and named by Richard Owen), *Echinorhynchus*, *Strongyloides*, and created the class "Sporozoa" among Protozoa. One of his last discoveries was that *Lymnaeus periger* serves as intermediary host to *Distomum hepaticum*, a discovery anticipated by a few weeks by Thomas of Oxford, who later became Professor at Christchurch, New Zealand. Much of Leuckart's original work is contained in his *Menschliche Parasiten*, etc., which went through two editions (1863 and 1876–1901) and was translated into English. Reference to the bibliographies below cited shows the wide range of his activities. His laboratory was a centre of keen research and many well-known parasitologists were his pupils.

For Biography see E. Ray Lankester (1901) in Obituary notices of Fellows of the Royal Society, *Roy. Soc. Year-book*, reprinted 1904, Pt I, pp. 19–22; R. Blanchard (1898), *Arch. de Parasitologie*, I, 185–190, with *portrait* and facsimile letter; V. L. Kellogg (1898), *Psyche*, Cambridge, Mass. VIII, 214–215; F. A. Zuern (1898), *Zeitschr. f. Thiermed.* Leipzig, II, 235–237. I have drawn from the first two sources.

For complete Bibliography see Leuckart's *Festschrift* (issued on the 50th anniversary of his professorial career); Stiles and Hassall (1906), *Index Catal. of Med. and Veter. Zool.* pp. 1078–1088. Our portrait is reproduced from one that appeared in the *München. med. Wochenschr.*

PIERRE JOSEPH VAN BENEDEN

1809—1894

Separate copies may be obtained from the University Press, Cambridge

RUDOLPH LEUCKART

1822--1898

Separate copies may be obtained from the University Press, Cambridge

PROSPERO SONSINO

1835—1901

Separate copies may be obtained from the University Press, Cambridge

ERRATUM.

Parasitology, xiv, p. 95, last paragraph.
For "Salmon and Stiles" *read* "Stiles and Hassall."

Prospero Sonsino

1835–1901.

(Portrait-plate XIV.)

SONSINO was born 6 August, 1835, at Tunis, of Italian parents, and died 19 November, 1901, at Montepiano, a village in the Apennines, Tuscany. He studied medicine at Pisa. In 1860–64 he travelled and practised his profession in Turkey and Asia Minor, then he settled in Florence, where he did public health work and edited a medical journal called the *Imparziale*, in which some of his papers appeared. In 1873–85 he resided in Egypt, practised and worked under very unfavourable conditions as micrographer to the Khedival Laboratory at Cairo, devoting himself specially to the parasitic worms of man and animals. He next travelled extensively in South America and the Far East as a ship's doctor, and returned to Pisa where he gave free courses in parasitology, revisiting Tunis (1893) and Egypt (1897) before he settled down finally in Montepiano.

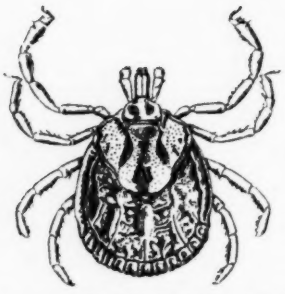
As a physician he did heroic work during cholera epidemics in Italy (1865) and subsequently in Egypt. Of his 139 publications, 70 (published in 1874–1901) relate to helminthology. He laid stress on the importance of helminths as a direct cause and indirect predisposing cause of disease at a time when all too little significance was attached to them by physicians. Sonsino attached much importance to the experimental study of helminthology. He wrote on Schistosomiasis in man and animals, *Filaria bancrofti*, *Ancylostoma duodenale*, *Distomum hepaticum*, and described a number of new and interesting species of helminths with which his name remains linked in the literature.

For a biography of Sonsino see Galli-Valerio (1906–7), *Arch. de Parasitol.* XI, 425–438, with *portrait* (herein reproduced) and signature (1893), a portrait on his death bed (1901), a facsimile of a letter, and bibliography; see also bibliography in Salmon and Stiles (1910), *Index Catal. of Med. and Vet. Zool.* pp. 2204–2211. Sonsino presented a collection of his papers to the writer in 1898, these papers being now in the Library of the Molteno Institute for Research in Parasitology.

NOTICE.

A *Bibliography on Hookworm Disease* of about 450 pages will shortly be ready for distribution as Publication No. 11 of the International Health Board. As the volume will be published in a limited edition, it is hoped that only individuals and institutions especially interested in the subject will apply for copies. Requests should be addressed to

THE ROCKEFELLER FOUNDATION,
61 BROADWAY,
NEW YORK CITY, N. Y.,
U. S. A.



TICKS

A Monograph of the Ixodoidea

Part I. **THE ARGASIDAE**, viii + 104 pp., 116 text-figures and 3 plates. Royal 8vo. 7*s*. 6*d*. net. (Appeared 1908.)

Part II. **IXODIDAE, THE GENUS IXODES**, xix + 243 pp., 192 text-figures and 4 plates. Royal 8vo. 14*s*. net. (1911.) For Bibliography, see below.

Part III. **IXODIDAE, THE GENUS HAEMAPHYSALIS**, xiii + 202 pp., 144 text-figures and 6 plates (2 coloured). Royal 8vo. 14*s*. net. (1915.) For Bibliography, see below.

By

GEORGE H. F. NUTTALL, F.R.S. and C. WARBURTON, M.A.

BIBLIOGRAPHY OF THE IXODOIDEA

Part I by G. H. F. NUTTALL, L. E. ROBINSON and W. F. COOPER. (2004 titles.) 7*s*. 6*d*. net. (1911.) Not sold separately from Part II of Text as above.

Part II by G. H. F. NUTTALL and L. E. ROBINSON. (462 titles.) 6*s*. 6*d*. net. (1915.) Not sold separately from Part III of Text as above.

N.B. These Bibliographies are an essential part of the work as they contain complete references to authors cited in the text and the references are frequently accompanied by notes in parentheses.

Postage extra on each part.

CAMBRIDGE UNIVERSITY PRESS
Fetter Lane, London, E.C. 4
C. F. CLAY, *Manager*.